ENGINEERING

McMaster University

Project Four – Power in Community:

Design a Device to Improve a Client's Daily Living

ENGINEER 1P13 – Integrated Cornerstone Design Projects

Tutorial T09

Team Thurs-41

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Academic Integrity Statement

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Executive Summary

For the past few weeks, our group has been working to design a device that would aid our client, an individual who has been struggling with Ehlers-Danlos Syndrome (EDS), a condition that affects the connective tissue. We had been tasked with coming up with a solution that makes the client's daily living better, whether that be some sort of aid while cooking, cleaning or exercising. The basis of our design was to aid our client in the process of cutting and preparing ingredients to cook. Our proposed solution had to be designed while keeping in mind some key factors pertaining specifically to our client. These factors included and were not limited to comfort, ergonomic, reducing lateral movement and strain among many others.

Figure 1. Design

Figure 2. Blade

Our team accomplished this by manufacturing the device that can be seen in Figure 1. Our design worked by first inserting your hand and securing it under the black wrist strap. The action of holding a knife can prove to have very awkward placement for one's fingers which is why decided to keep our client's hand flat. To provide comfort, the wrist strap was lined with a soft fabric lining and the resting block where our clients hand would rest has small divots to provide extra support to the carpometacarpal and metacarpophalangeal joints. The cutting board itself contained a sliding piece that would provide ease in the retrieval of food once it had been cut. Once the sliding insert piece was taken out, the food would be stored in the drawer that can be seen under the cutting board in Figure 1. The bottom of the cutting board had rubber slip stoppers to increase friction between the cutting board and the surface it was resting on to decrease the likelihood of the board slipping and causing an injury. As seen in Figure 2, the blades used are in a square

orientation allowing for versatility while cutting. Along with the increased versatility, the blades are easily replaceable as well due to them being 3D printed with PLA (polylactic acid) filament, which is in fact food safe.

Our proposed solution has multiple benefits for the client. Firstly, our design works to reduce strain on the user's hand while cutting. This is accomplished by implementing several design considerations. These include a flat hand placement that will help distribute the load instead of overloading a specific joint in the hand. The use of small divots also helps with the distribution of the load evenly throughout the client's hand. Additionally, introducing 4 detachable components, sliding drawer, insert piece, blade insert and blade holder, proves to aid in the process of cleaning along with the storage of the device when it is not in use. Finally, the use of 3D printed blades can prove to be quite beneficial as well. With the use of PLA filament along with a high infill, not only are the blades food safe, but they are also quite durable as well. Using 3D printed blades also allows our clients to replace them easily as he has access to a 3D printer enabling him to replace the blades whenever need be with little cost.

Figure 3. Slicer Strap

Moving forward, our solution still has ample of room for improvement. If given more money, resources and time, our team could focus on implementing some sort of adjustment that would allow our client to modify the height of our device. By doing so, our client would be able to place different sized drawers under the cutting board. This would also allow him to find the height that is best for him which would further increase the comfort. Furthermore, looking to use more food safe materials such as different cuts of wood along with polished wood would be quite beneficial if given an increased budget. Refining the handle seen in Figure 3 to cater more towards client specifications, such as his overall hand measurements and what feels most comfortable for him, would further increase the ergonomic basis of our design.

Main Body

Introduction

EDS, short for Ehlers-Danlos Syndrome, is used to describe a variety of connective tissue disorders which caused the clients' disabilities to live their normal lives. This is caused by specific gene failures which weaken the connective tissues, which are sometimes inherited [1]. The common symptoms of EDS include overly flexible joints, as well as stretchy and fragile skin [2]. According to our client, he is frequently injured while going about his day-to-day life and many physical therapies such as Tai chi do not seem to help. He also mentioned how bothered he was in his everyday life while doing common tasks in the kitchen such as cutting. The common position of holding a knife is to put the handle between thumb and index finger, which uses the hand component between them to push the knife downwards to cut. This position applies a significant amount of pressure to both the carpometacarpal and basal carpometacarpal joints [3]. This causes the client with EDS hard to operate with the common knives in current market. In this case, we decided to design a cutting board for the client to cut some simple things in the kitchen. The carpometacarpal and basal carpometacarpal joints [3]. The strain placed on these joints causes the client a lot of difficulty when operating knives, which are currently the main cutting method in the commercial market. We wanted to design a solution that would not require our client to bend his fingers to grip something such as a knife handle. Therefore, our refined problem statement was to design an ergonomic means to assist our client, who lives with Ehlers-Danlos syndrome which causes him to experience a lot of pain, when completing simple daily tasks related to cooking such using a knife. The means will be designed for use in his home to ease the completion of these tasks, which is an essential function. The device should be lightweight and versatile. It should also reduce lateral movement of the hand and strain on the joints that would be experienced without the use of the device. We refer to our design as a fold over slicer with a cutting board attachment. Some objectives of our design were that it should be lightweight, ergonomic, and adaptive. These were all important in ensuring the device was user friendly and comfortable for the client to use, as well as practical so he would be able to cut various kinds of food objects in either a lengthwise or widthwise orientation. A few constraints of our design were that it needed to be made of food-safe materials, the user's hand placement was flat, and the blades were detachable. Since this device is meant to be used in the kitchen and will encounter food, the materials needed to be food safe. Keeping the user's hand flat while operating the device was necessary to remove the significant amount of stress applied to the two hand joints previously mentioned, which was one of the functions our design aimed to achieve. Making the blades detachable was also a condition that needed to be met for safety purposes, especially when the device was in

storage, so the blades could be stored separately and were not at risk of falling out when the device was being transferred by the user either into or out of storage.

Conceptual Design

The ideation process began during our introduction lecture with James where we were required to take notes on his experience with Ehlers-Danlos syndrome and daily tasks he struggles with. After combining all our notes together, we created a very general initial problem statement avoiding any solution-specific terms: design a means that makes the client's day-to-day tasks easier to do by reducing physical strain placed on his joints. From there, we created an objective tree which helped us develop an idea of how we could ensure our design achieved its main objectives by incorporating certain design requirements. Additionally, developing a test plan to determine whether our objectives were being met using specified metrics was especially important to refer to later in the project when we had a functioning prototype. Creating rough sketches and completing a functional analysis was extremely helpful for brainstorming purposes as we were able to translate the previous research we had done into a visual of a potential prototype. Taking these sketches and turning them into a physical prototype made of whatever materials we had available to us was the most crucial point in our design exploration. We were able to identify certain features of each team member's prototype that we liked and that lead to our final prototype incorporating aspects from all initial prototypes. When points were being assigned to certain designs in our weighted decision matrix, as seen in Section 2 of Appendix A, we had a clear frontrunner which was a cutting board design with attachments to hold a knife and food object in place. Naturally, that was one of our choices to present to the science students during the first design review, alongside the slicer with a handle model. Our two other design ideas were a resting block to sit on top of a device, as well as a fold-over slicer with a similar concept to an egg slicer. The feedback we received during the first design review really drew our attention to materials selection for fabrication, as they needed to be food-safe and ideally dishwasher friendly. Additionally, incorporating a way for him to be able to cut both lengthwise and widthwise for the slicer with a handle model was a point made by our TA that altered our final design size-wise so we could include this refinement. After the conclusion of the first design review, we realized that it would be a lot easier to change features on the slicer model rather than on the cutting board. This changed our design process greatly as we had originally thought we would proceed with strictly the cutting board model, but we had the idea to still use a cutting board with the slicer attached to the board as well. This model, a hybrid of two of our initial prototypes, was the prototype we brought to the second and final design review. The feedback we received during this review included adjusting the height of the cutting board, incorporating a drawer feature, making the blades

detachable and durable, and finding a way to secure the model to the countertop where it would be used by the client. We did our best to incorporate as many of these suggestions into our final design as possible to ensure it was safe and user-friendly for our client.

Final Proposed Design

The final design was officially made after making several iterations to our initial prototype. The final design is comprised of several components including a cutting board, a cut-out in the cutting board, a handle on the cut-out, slicer, slicer strap, blades, blade inserts, hinges and pins, nails, drawer, and plastic no-slip stoppers. Using these components, our team created the alternate method for cutting, which is the fold over slicer.

To operate the device, the user will place the cutting board on a flat surface. The user will slide in the cut-out and secure in place. Then, the user will attach the slicer to the cutting board by placing the pins through the hinges. After this, the user will insert the blade insert piece with the blades attached into the slicer attachment. The user will slide their hand under the slicer strap and lining. After this, the user will grip the sides of the slicer while being supported by the flat surface of the slicer and the comfortable strap. Using this grip, the user will rotate the slicer and blades will cut the food product on the cutting board. After cutting the food product, the user can grab the handle on the cut-out and pull it outwards to allow the food to fall through and into the drawer. Once the user is finished using the device, they can pull the drawer out and move the food elsewhere. The blades and blade insert can be removed. The pins in the hinge can be removed to detach the slicer from the cutting board. These components can be washed in a dishwasher for easy cleaning. This is essentially the full process of how the design operates.

This design has various specifications. One specification includes the divots sanded into the top of the slicer piece, which supports the client's hand joints. The slicer is specifically designed to fit the client's hand comfortably on the top of the slicer to reduce any discomfort and lateral movement of his hand joints. Using the pictures of James' hands that were provided, we were able to map out the dimensions of his right hand to create the indents in the correct positions on the slicer [3]. Using this, we ensured that the slicer strap was also about 5 inches wide to make sure his hand can fit under it with ease [3]. We also made the dimensions of the slicer slightly bigger than James' hand and wrist to ensure that it can rest comfortably on the slicer while using the design. We also lined the inside of the slicer strap with cotton to provide a soft layer of support that will be comfortable for the client's hand. The area where the client would grip the slicer once his hand is placed under the strap, is sanded down to create curved/rounded edges to reduce discomfort.

Our final drawings of the design were done on Inventor using the measurements from our refined initial prototype. They were then turned into 3D parts using mainly the extrude tool so that we could assemble them into our prototype after they were fabricated. The assembly of our prototype can be seen in Figure 4 below.

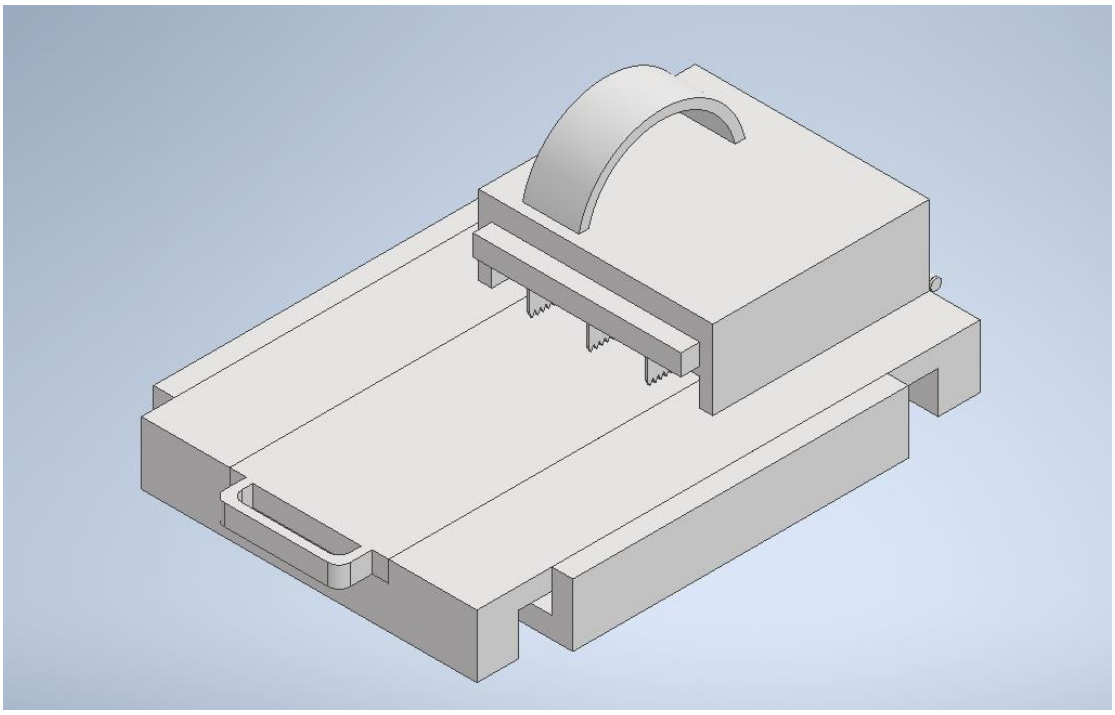

Figure 4. Assembly in Inventor of all of our prototype's components with correct measurements

There are various objectives and constraints that our final design met. Our three main objectives were ergonomic, lightweight, and adaptive. Our design has met these objectives, which were determined by the metrics associated with them. After testing out the design through various peers including our design reviewers, we were told that the injury factor of our design or the rate of injury has been lowered compared to using a regular knife. The estimated weight of the prototype is around 2 kilograms, which was measured using a scale. This means that our design is also quite lightweight. Our design is also adaptive as it can cut various small sized food products, as we have tested the design with various fruits such as bananas, grapes, kiwi, and strawberries. Some constraints we came up for our design include having it weight less then 5 pounds. This is because it should be easy for the client to carry the device.

There were a few construction methods we used to fabricate the final design. This included a combination of 3D printing and woodworking. We decided to 3D print the blades and the slicer strap components of the design. The material used was PLA, which is easy to clean. This is why we chose this material. The blades will be making contact with the food products, so these would need to be easily cleansed.

The client also has access to 3D printing at his residence, which means we could replace the blades by printing new ones. From touching food products, the client's hands could get dirty as would the slicer strap. The PLA would be easy to clean for the client. We used metal nails and hinges to attach the slicer to the cutting board. We used metal as the material needs to be sufficiently durable to withstands the weight of the slicer on the cutting board and the client's hand on the top of the slicer. We used layers of cotton material to line the underside of the slicer strap. This is because cotton is a very smooth and soft material, which will be able to support James' hand and provide comfort while the strap secures his hand in place. The bottom of the cutting board has stoppers to ensure the cutting board stays in place. We used plastic stoppers to ensure they grip kitchen counters nicely. The main components of the design including the cutting board, cut-out, cut-out handle, drawer, slicer, and blade insert piece were all made out of wood. After purchases various sizes of wood from Home Depot, we used a miter saw to cut the pieces of wood to the correct dimensions. Using wood glue, we pieced together the wood. This is the construction and fabrication process we used to create our final design.

Table 1. Bills of Materials

Design Component	Material	Quantity	Cost for Parts ($)
Cutting Board, Cut-out, Cut-out Handle, Drawer Handle, Drawer, Slicer, and Insert Piece	Wood	6	$86.53
Blades	PLA	3	$0.00
Slicer Strap	PLA	1	$0.00
No Slip Stoppers	Plastic	6	$0.00
Hinges	Metal	2	$0.00
Nails	Metal	8	$0.00
Slicer Strap Lining	Cotton	1	$0.00
Total Cost			$86.53

Conclusions

If we were given more time, a few steps we would take to improve our device would be researching other materials to fabricate blades out of, creating a guard or cover for the blades, and experimenting with the height of the cutting board. Due to a resource limitation, we were only able to 3D print the blades using PLA

filament with a serrated edge, which worked for the purposes of showing the functionality of our design. However, to make this product more commercial grade we would have investigated using either plastic or metal knife blades which would have been sharper and easier to cut with. Creating a cover or guard for the blades was another idea we had but were not able to create due to a lack of time left in the project. Making a functional prototype was our main goal and although a guard would have been a great safety feature, we chose to focus our time and energy on the fabrication of the cutting board and slicer.

Additionally, experimenting with the height of the cutting board was a metric we talked about to test how ergonomic our design would be for the client to use. We did not want the board to be too tall or short as that would cause unnecessary strain on the client's back and shoulders by him having to either hunch over or stand too upright while operating the device. Therefore, finding an equilibrium height where his back and shoulders would not have to be over engaged when using the device would be ideal. We were only able to estimate this approximate height of the cutting board given his body measurements and some research done but having him test out the device and tell us what felt most comfortable would be the most ideal design input. Another option we considered later in the project was making the height of the cutting board adjustable so other people in his household could use it as well, but again we did not have the time to explore this design alternative.

Reflecting on the few weeks during which this project took place, our view of the design process was altered quite a bit. We realized that having to take a step back in the process and rethink some previous design decisions is not necessarily bad and is sometimes needed to better understand the problem being dealt with. The most important lesson we learned about team dynamics is that communicating openly with your team members is the key to success. Talking through any potential ideas or concerns we had with the design was always welcomed and often lead to others sharing their ideas about modifications that could better our design overall. An interesting feature about our final prototype was that it was a combination of two of our initial prototypes, which would not have occurred without a collaborative effort between all group members to bring those two ideas together and turn them into a functional design. Even though two ideas meant to achieve the same task may seem quite different in their own ways, it is possible to fuse them together into a single design to solve a problem in a more well-rounded manner.

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Source Materials Database:

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Appendix A – Supporting documents

Section 1

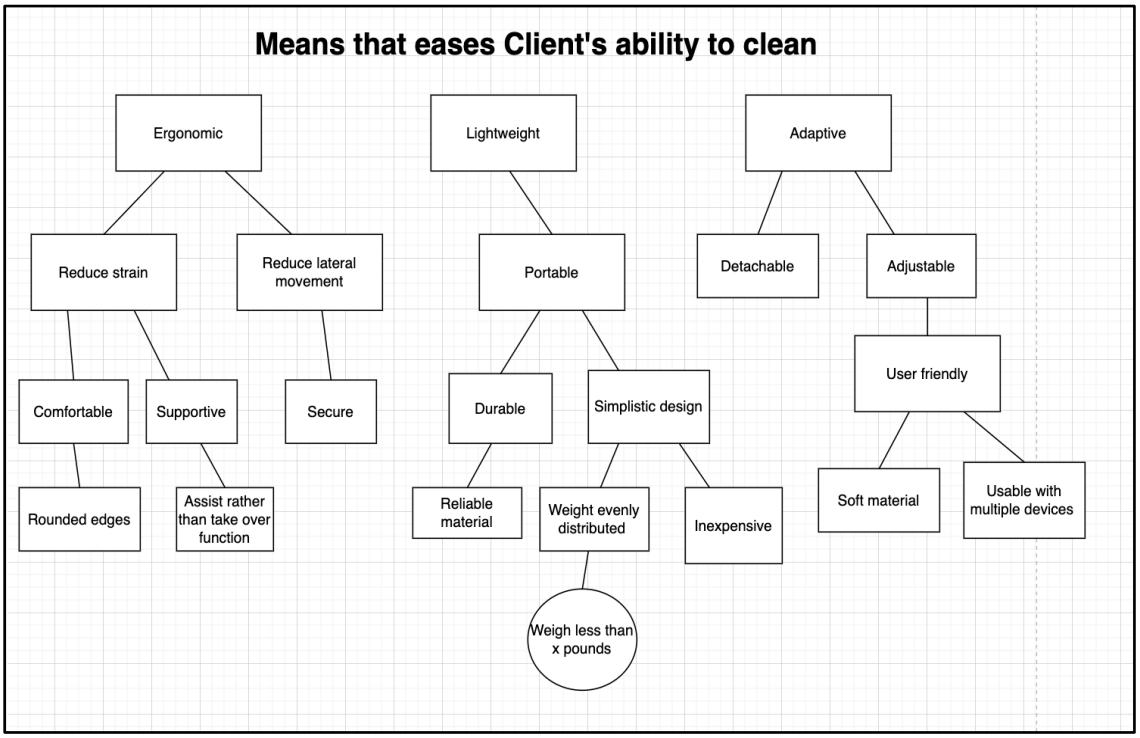


Figure 5. Objective Tree

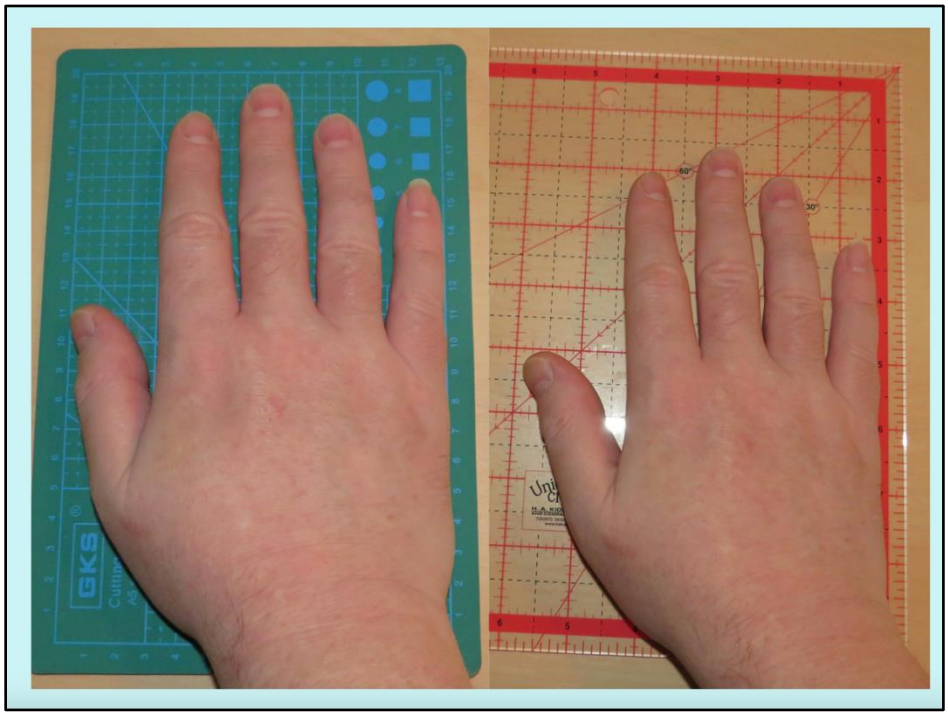
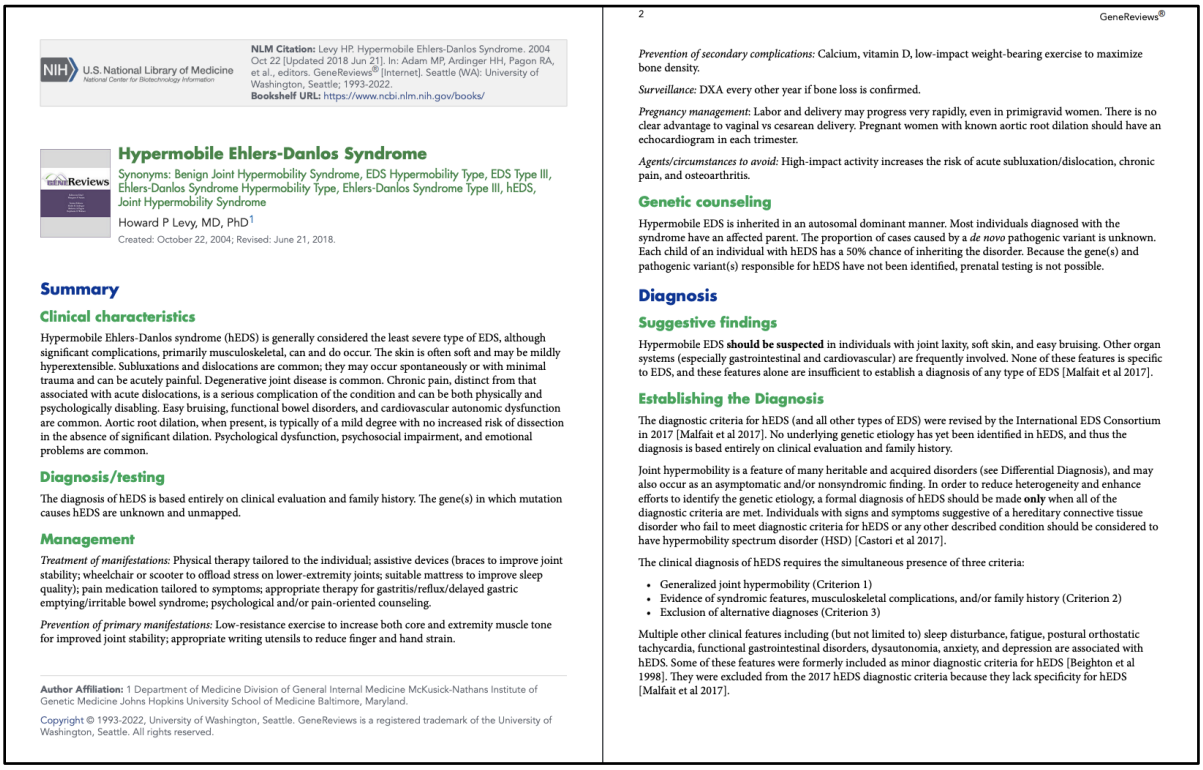


Figure 6. Measurements of client's right hand (from entry [4] in the List of References)

Figure 7. Commercial product by Zyliss (from entry [4] in Source Materials Database)



NIH U.S. National Library of Medicine National Center for Biotechnology Information

NLM Citation: Levy HP. Hypermobile Ehlers-Danlos Syndrome. 2004 Oct 22 [Updated 2018 Jun 21]. In: Adam MP, Ardinger HH, Pagon RA, et al., editors. GeneReviews® [Internet]. Seattle (WA): University of Washington, Seattle; 1993-2022.
Bookshelf URL: https://www.ncbi.nlm.nih.gov/books/

GeneReviews

Hypermobile Ehlers-Danlos Syndrome

Synonyms: Benign Joint Hypermobility Syndrome, EDS Hypermobility Type, EDS Type III, Ehlers-Danlos Syndrome Hypermobility Type, Ehlers-Danlos Syndrome Type III, hEDS, Joint Hypermobility Syndrome

Howard P Levy, MD, PhD[1]

Created: October 22, 2004; Revised: June 21, 2018.

Summary

Clinical characteristics

Hypermobile Ehlers-Danlos syndrome (hEDS) is generally considered the least severe type of EDS, although significant complications, primarily musculoskeletal, can and do occur. The skin is often soft and may be mildly hyperextensible. Subluxations and dislocations are common; they may occur spontaneously or with minimal trauma and can be acutely painful. Degenerative joint disease is common. Chronic pain, distinct from that associated with acute dislocations, is a serious complication of the condition and can be both physically and psychologically disabling. Easy bruising, functional bowel disorders, and cardiovascular autonomic dysfunction are common. Aortic root dilation, when present, is typically of a mild degree with no increased risk of dissection in the absence of significant dilation. Psychological dysfunction, psychosocial impairment, and emotional problems are common.

Diagnosis/testing

The diagnosis of hEDS is based entirely on clinical evaluation and family history. The gene(s) in which mutation causes hEDS are unknown and unmapped.

Management

Treatment of manifestations: Physical therapy tailored to the individual; assistive devices (braces to improve joint stability; wheelchair or scooter to offload stress on lower-extremity joints; suitable mattress to improve sleep quality); pain medication tailored to symptoms; appropriate therapy for gastritis/reflux/delayed gastric emptying/irritable bowel syndrome; psychological and/or pain-oriented counseling.

Prevention of primary manifestations: Low-resistance exercise to increase both core and extremity muscle tone for improved joint stability; appropriate writing utensils to reduce finger and hand strain.

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Prevention of secondary complications: Calcium, vitamin D, low-impact weight-bearing exercise to maximize bone density.

Surveillance: DXA every other year if bone loss is confirmed.

Pregnancy management: Labor and delivery may progress very rapidly, even in primigravid women. There is no clear advantage to vaginal vs cesarean delivery. Pregnant women with known aortic root dilation should have an echocardiogram in each trimester.

Agents/circumstances to avoid: High-impact activity increases the risk of acute subluxation/dislocation, chronic pain, and osteoarthritis.

Genetic counseling

Hypermobile EDS is inherited in an autosomal dominant manner. Most individuals diagnosed with the syndrome have an affected parent. The proportion of cases caused by a *de novo* pathogenic variant is unknown. Each child of an individual with hEDS has a 50% chance of inheriting the disorder. Because the gene(s) and pathogenic variant(s) responsible for hEDS have not been identified, prenatal testing is not possible.

Diagnosis

Suggestive findings

Hypermobile EDS **should be suspected** in individuals with joint laxity, soft skin, and easy bruising. Other organ systems (especially gastrointestinal and cardiovascular) are frequently involved. None of these features is specific to EDS, and these features alone are insufficient to establish a diagnosis of any type of EDS [Malfait et al 2017].

Establishing the Diagnosis

The diagnostic criteria for hEDS (and all other types of EDS) were revised by the International EDS Consortium in 2017 [Malfait et al 2017]. No underlying genetic etiology has yet been identified in hEDS, and thus the diagnosis is based entirely on clinical evaluation and family history.

Joint hypermobility is a feature of many heritable and acquired disorders (see Differential Diagnosis), and may also occur as an asymptomatic and/or nonsyndromic finding. In order to reduce heterogeneity and enhance efforts to identify the genetic etiology, a formal diagnosis of hEDS should be made **only** when all of the diagnostic criteria are met. Individuals with signs and symptoms suggestive of a hereditary connective tissue disorder who fail to meet diagnostic criteria for hEDS or any other described condition should be considered to have hypermobility spectrum disorder (HSD) [Castori et al 2017].

The clinical diagnosis of hEDS requires the simultaneous presence of three criteria:

- Generalized joint hypermobility (Criterion 1)
- Evidence of syndromic features, musculoskeletal complications, and/or family history (Criterion 2)
- Exclusion of alternative diagnoses (Criterion 3)

Multiple other clinical features including (but not limited to) sleep disturbance, fatigue, postural orthostatic tachycardia, functional gastrointestinal disorders, dysautonomia, anxiety, and depression are associated with hEDS. Some of these features were formerly included as minor diagnostic criteria for hEDS [Beighton et al 1998]. They were excluded from the 2017 hEDS diagnostic criteria because they lack specificity for hEDS [Malfait et al 2017].

Figure 8. Medical document from Gene Reviews (from entry [5] in Source Materials Database)

Note: Client Meeting notes are included in Milestone 1 and 2 worksheets.

Section 2

Table 2. Weighted Decision Matrix

Project 4 Prototypes: Weighted Decision Matrix									
	Weighting	*Prototype 1: Slicer with a Handle*		*Prototype 2: Cutting Board attachment*		*Prototype 3: Hand rest attachment for knife*		*Prototype 4: Fold over slicer*	
		Score	Total	Score	Total	Score	Total	Score	Total
Criterion 1: Hand remains in comfortable resting position	4	2	8	3	12	5	20	3	12
Criterion 2: Restrict excessive wrist movement	3	3	9	2	6	4	12	2	6
Criterion 3: Distribute pressure applied by user	3	4	12	3	9	5	15	2	6
Criterion 4: Able to cut various food products	5	3	15	5	25	5	25	2	10
Total Score			44		52		72		34

Table 3. Morph Chart

Function	**Means**					
Keep hand flat during motion	Strap	Brace	Wrap	Stabilizer	Platform	Resistive band
Distribute pressure applied by user	Large diameter	Large grip	Rounded edges	Long handle	Extendable handle	Placement of the hand
Restrict excessive movement of wrist while pivoting	Smooth material	Mouldable material	Components fit for client (based on measurements)	Adjustable components	Supports	Angle constraint (when hand is tilted)

Note: Initial Concept Sketches are included in the Milestone 2 worksheet.

Note: Design review notes are included in the Milestone 3 (1st review) and Milestone 4 (2nd review) worksheets.

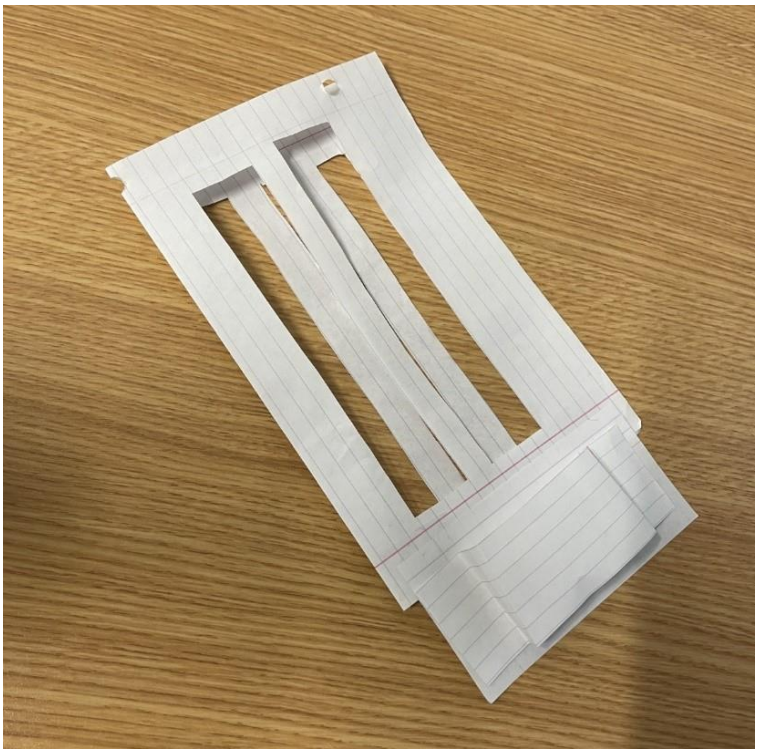


Figure 9. Refined Concept Initial Prototype #1

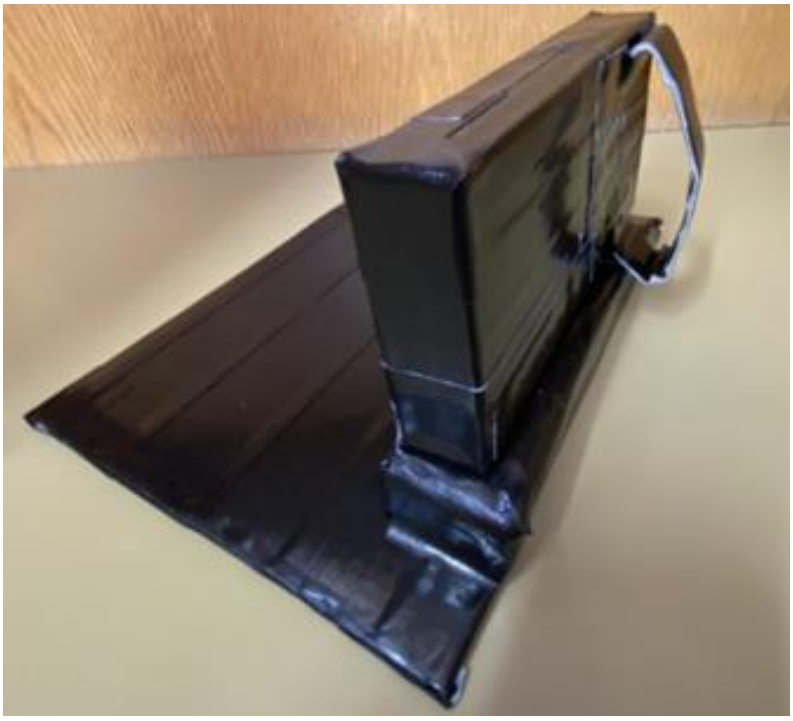


Figure 10. Refined Concept Initial Prototype #2

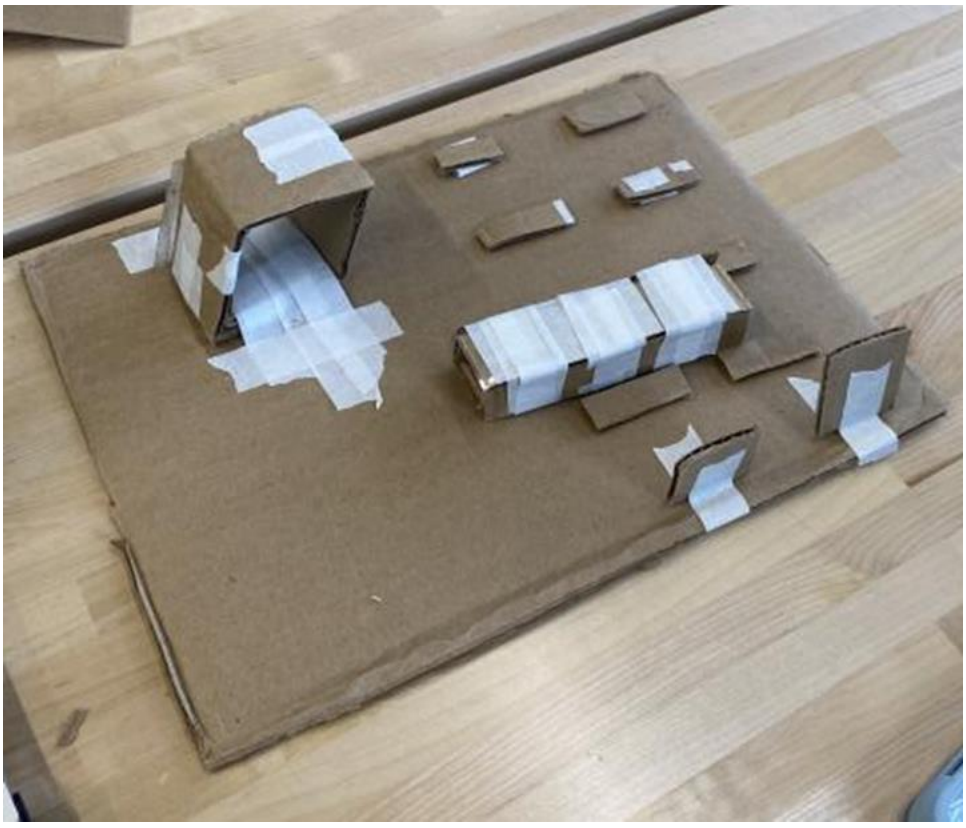


Figure 11. Refined Concept Initial Prototype #3

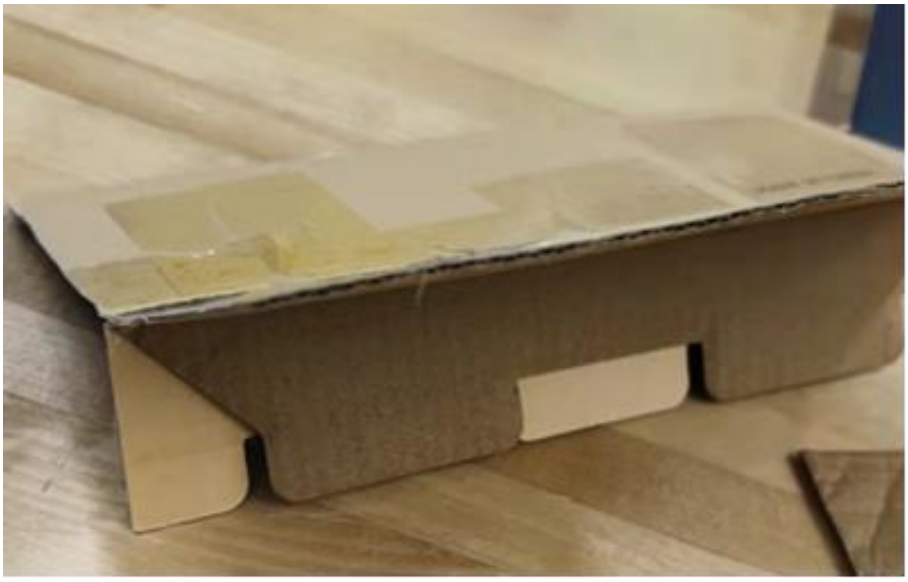


Figure 12. Refined Concept Initial Prototype #4

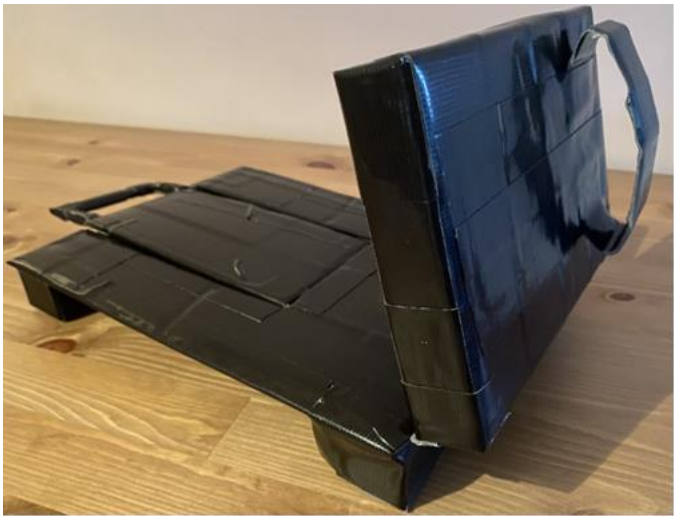


Figure 13. Refined Initial Prototype (for design review 2)

Figure 14. Refined Initial Prototype (for design review 2)

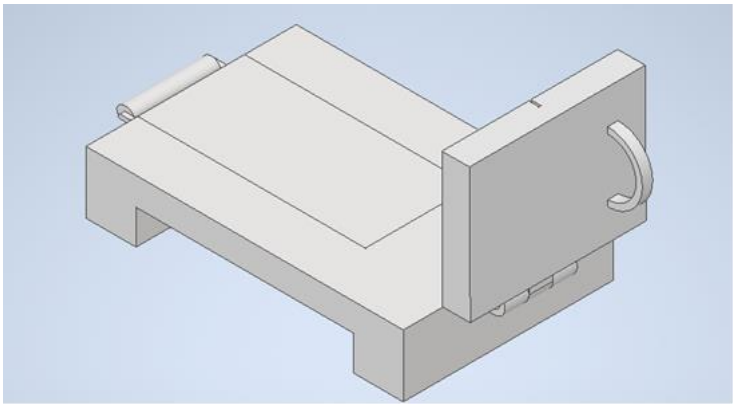


Figure 15. CAD model of Refined Initial Prototype

Section 3

Modelling: Final Model Assembled

Figure 16. Front View of Model in Closed Position

Figure 17. Right View of Model in Closed Position

Figure 18. Back View of Model in Closed Position

Figure 19. Right Corner of Model in Closed Position

Figure 20. Front View of Model in Opened Position

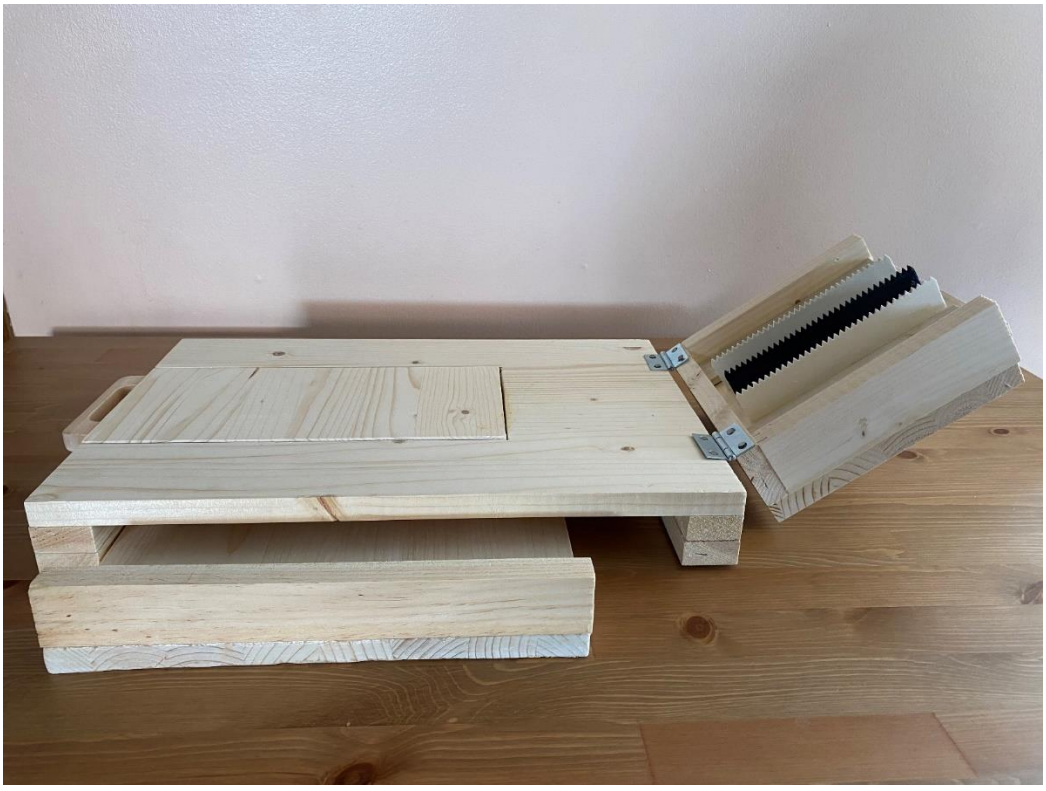


Figure 21. Right View of Model in Opened Position

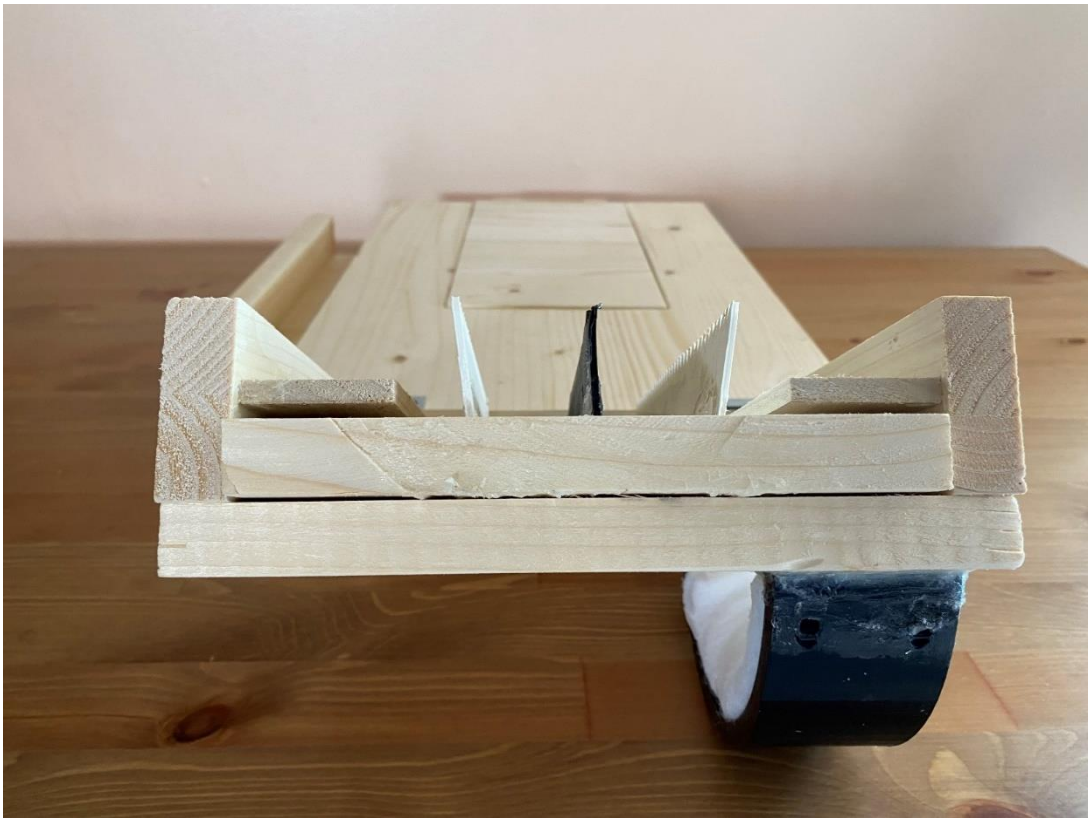


Figure 22. Back View of Model in Opened Position

Figure 23. Right Corner of Model in Opened Position

Modelling: Final Model Individual Parts

Figure 24. Cutting Board with Cut-out in Place

Figure 25. Cutting Board without Cut-out Piece

Figure 26. Cut-out Piece from Cutting Board with Handle

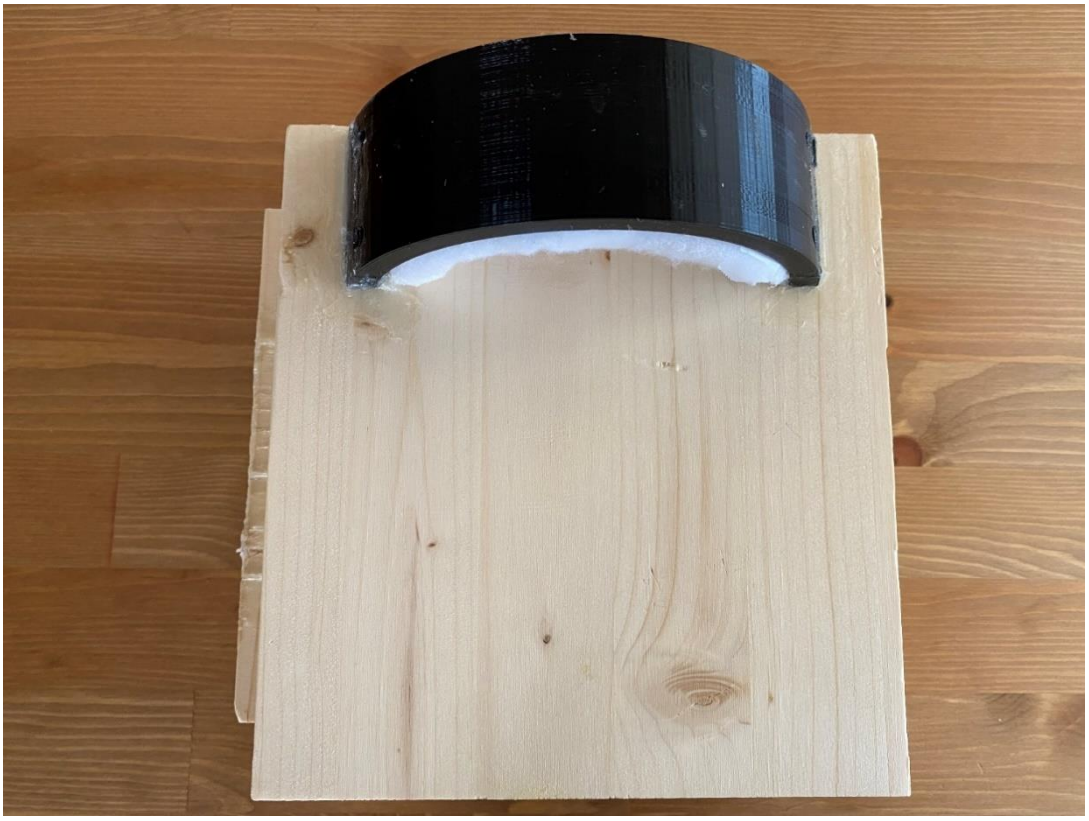


Figure 27. Slicer Strap with Lining

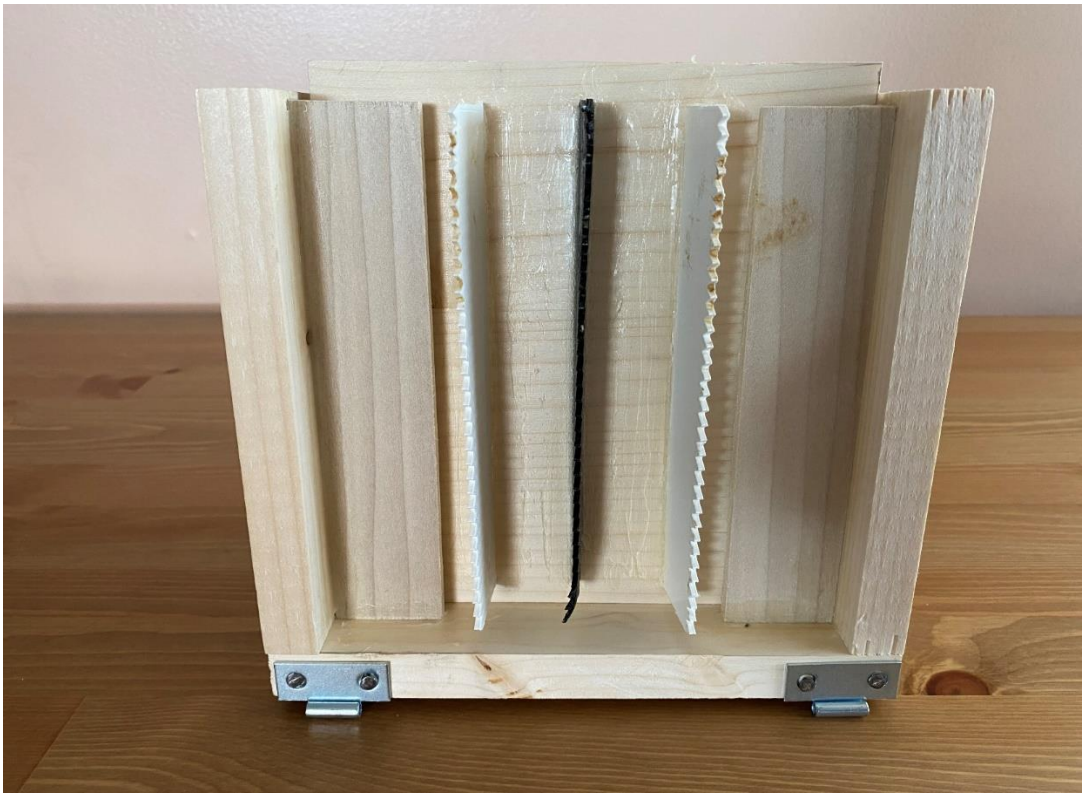


Figure 28. Slicer with Blade Insert Piece

Figure 29. Slicer without Blade Insert Piece

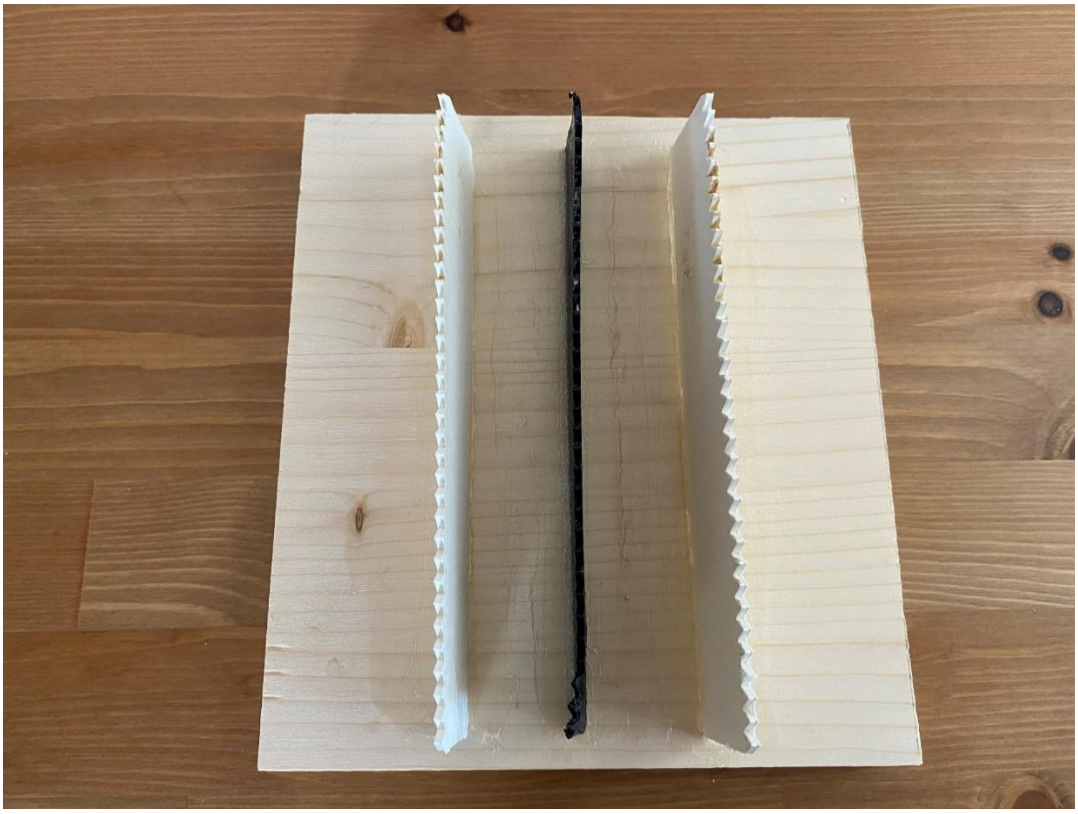


Figure 30. Blade Insert Piece

Figure 31. Drawer

Modelling: AutoDesk Inventor Assembly of Parts

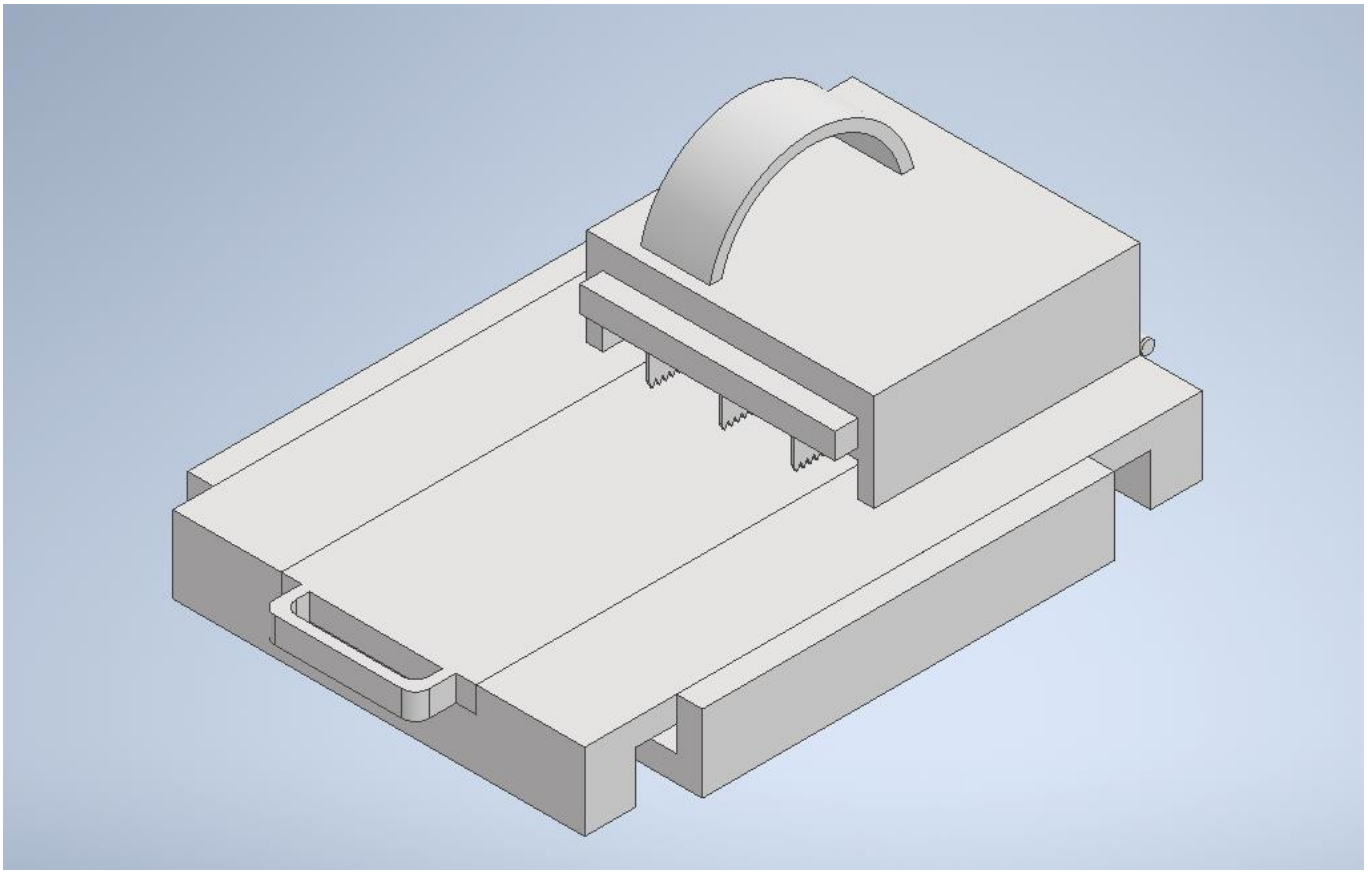


Figure 32. CAD model of Final Refined Prototype

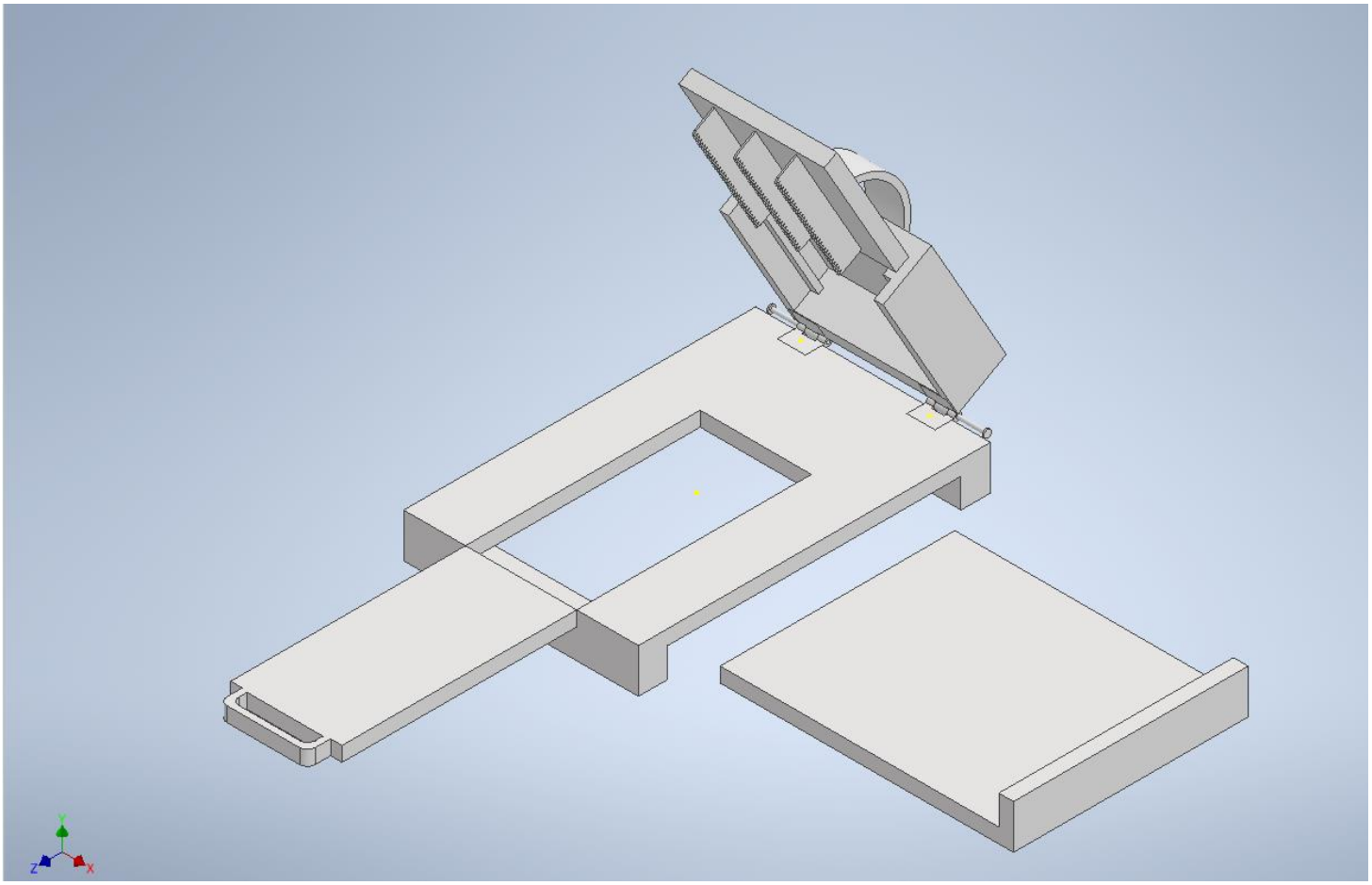


Figure 33. CAD model of Final Refined Prototype with Detachable Components removed

Modelling: AutoDesk Inventor Individual Parts of Model

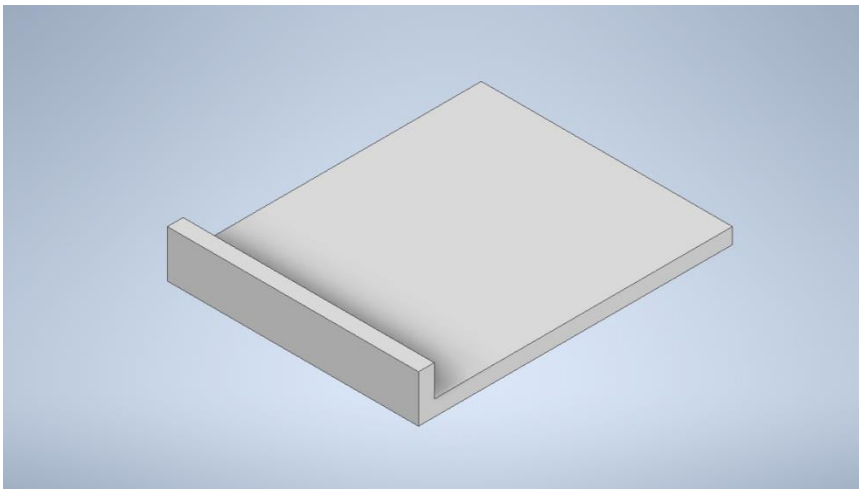


Figure 34. Detachable drawer component to store cut food

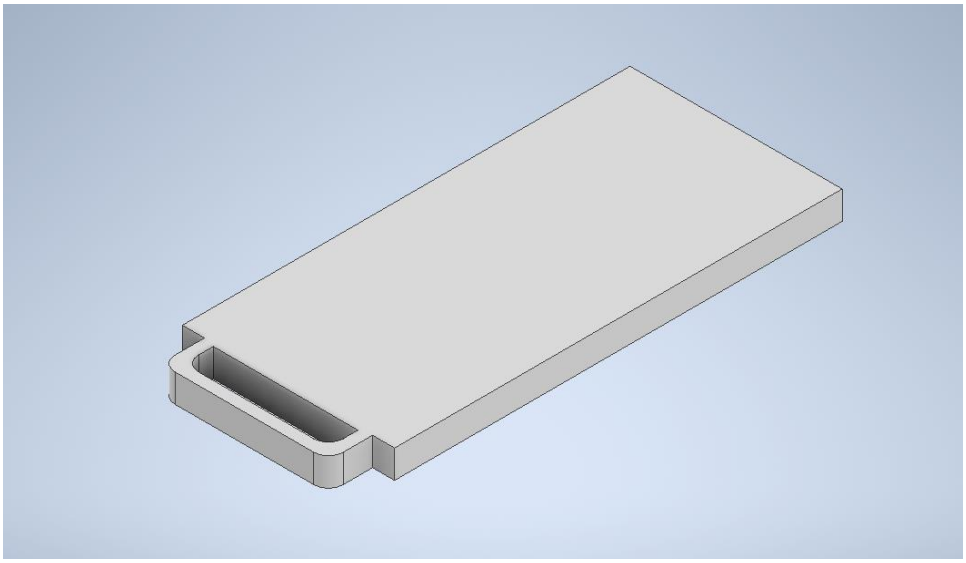


Figure 35. Detachable cut-out in cutting board to remove cut food

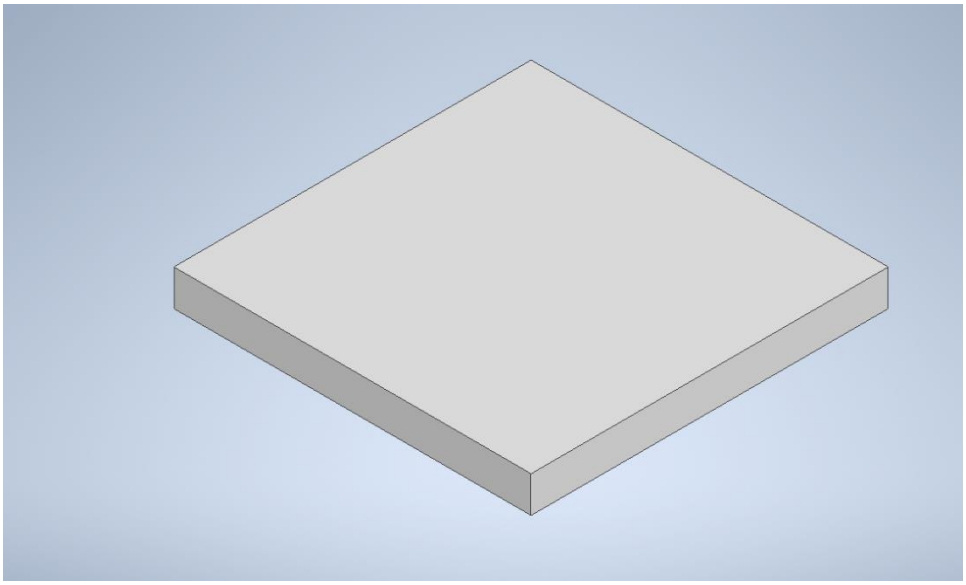


Figure 36. Slicer insert that the blades are attached to

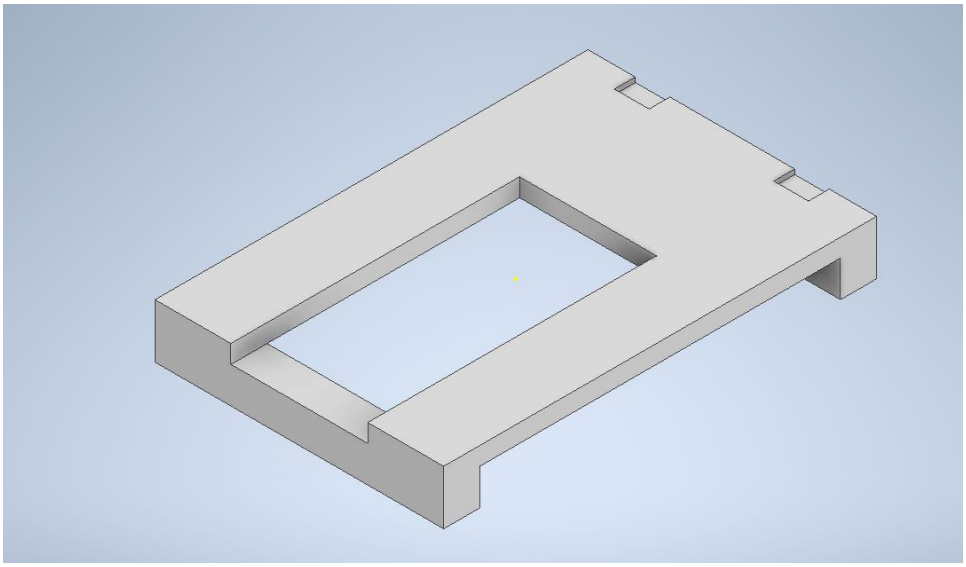


Figure 37. Cutting board component with cut-outs for detachable components

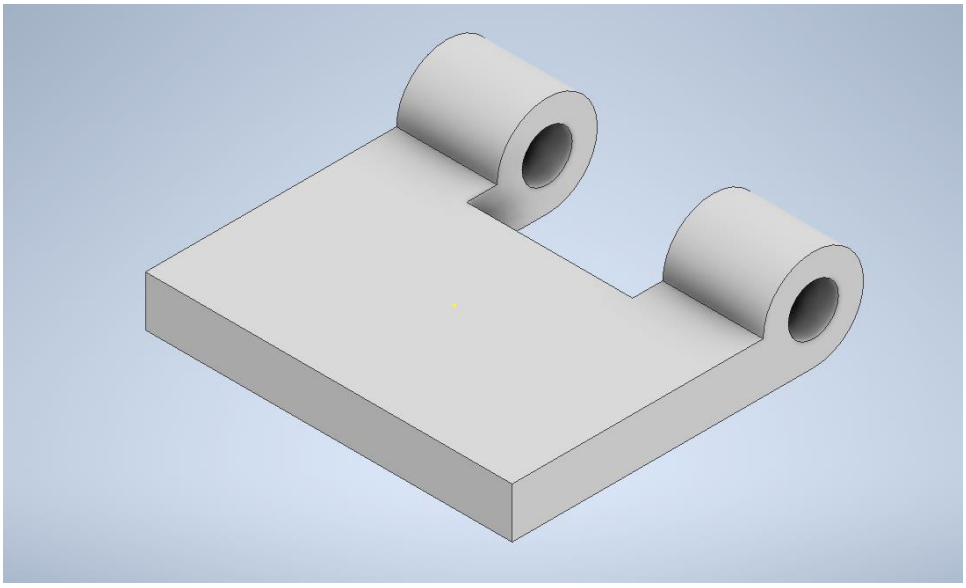


Figure 38. One of two hinge components

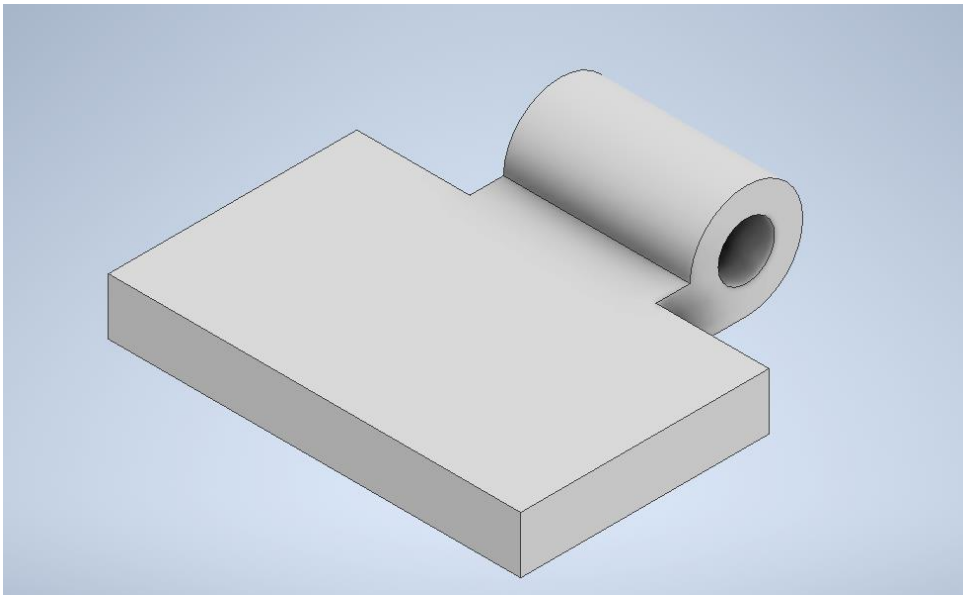


Figure 39. Second of two hinge components

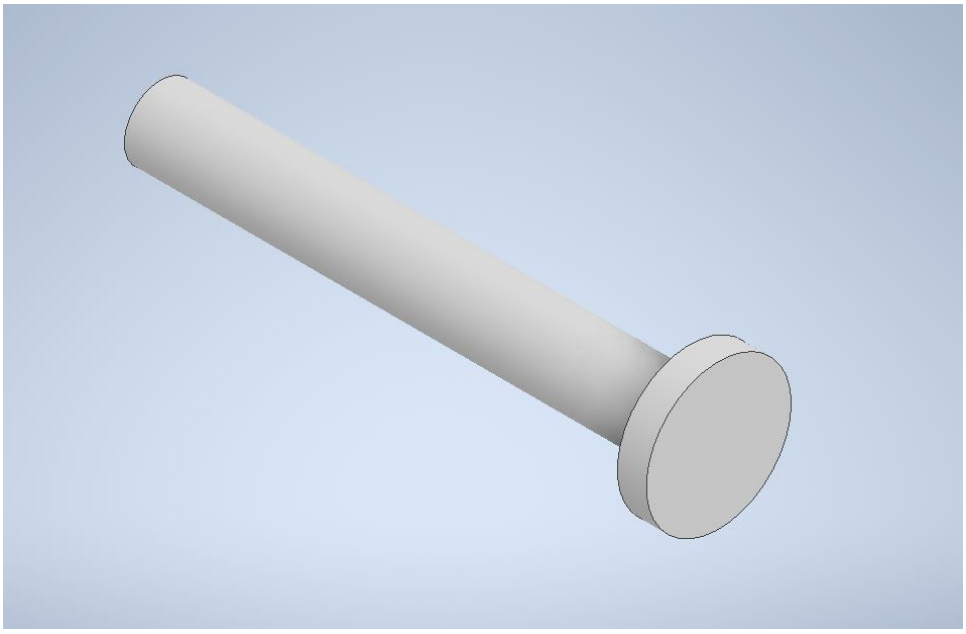


Figure 40. Connecting pin for two hinge components

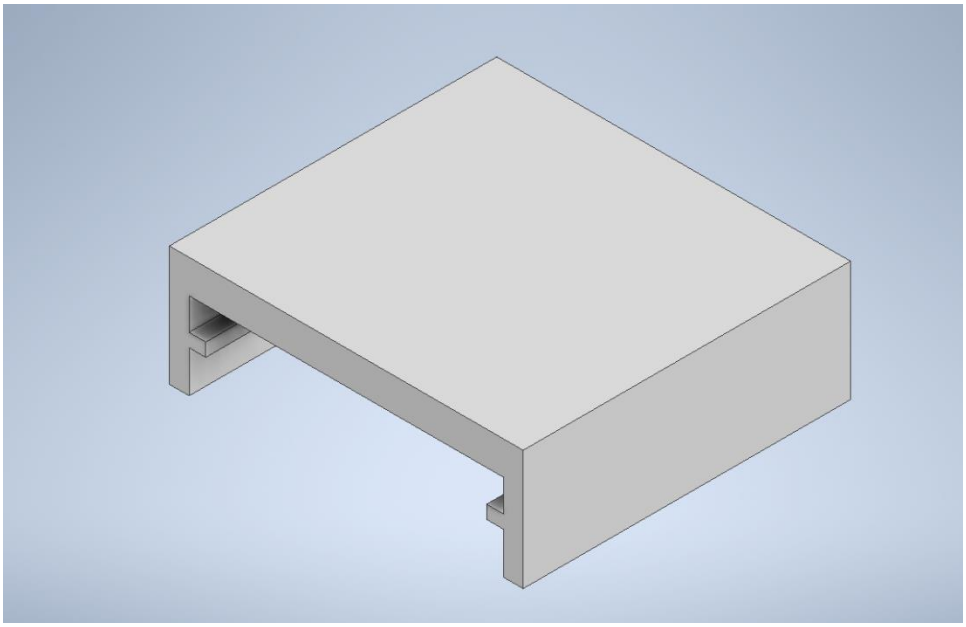


Figure 41. Right corner view of slicer attachment

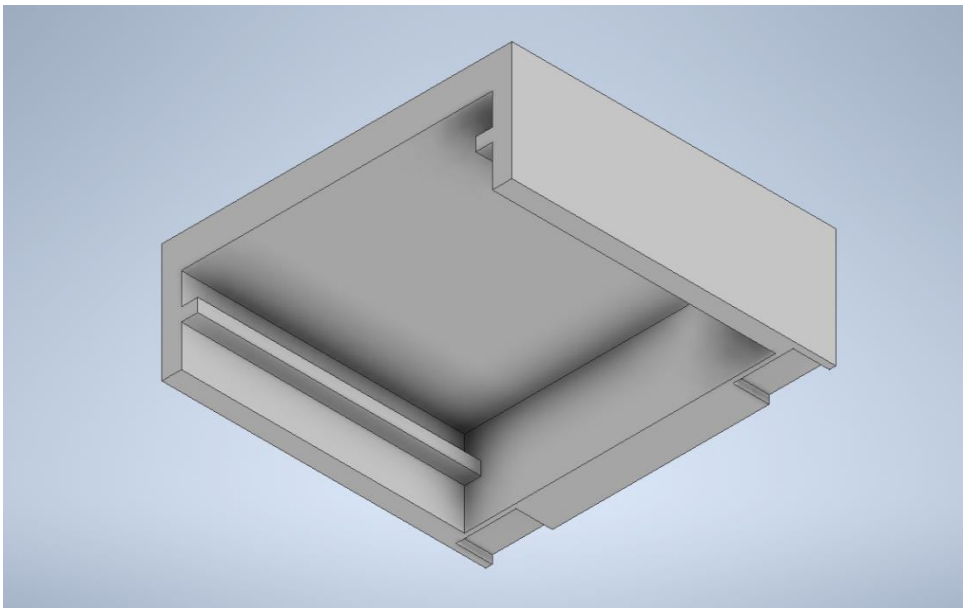


Figure 42. Bottom right corner view of slicer attachment

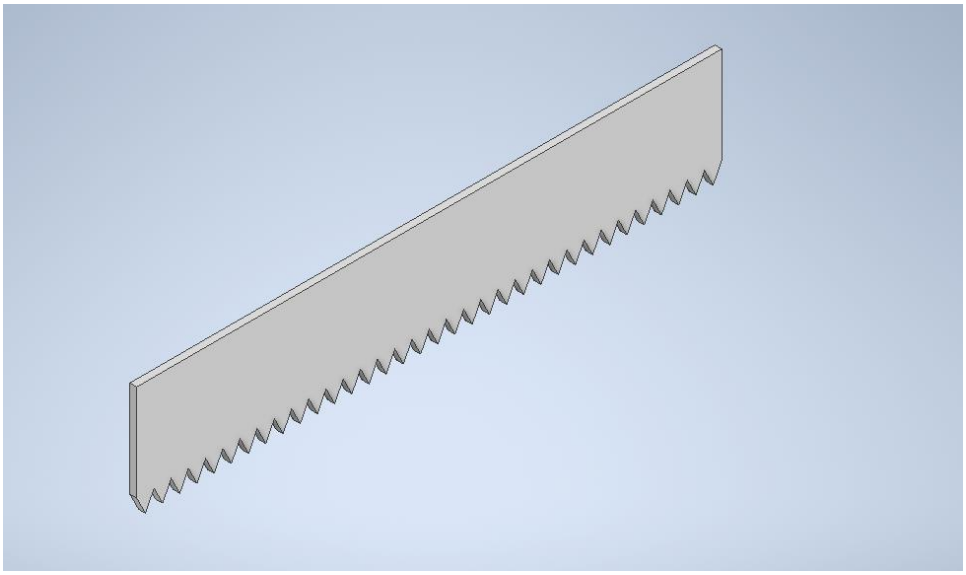


Figure 43. Blade that attaches to slicer insert (3 identical blades)

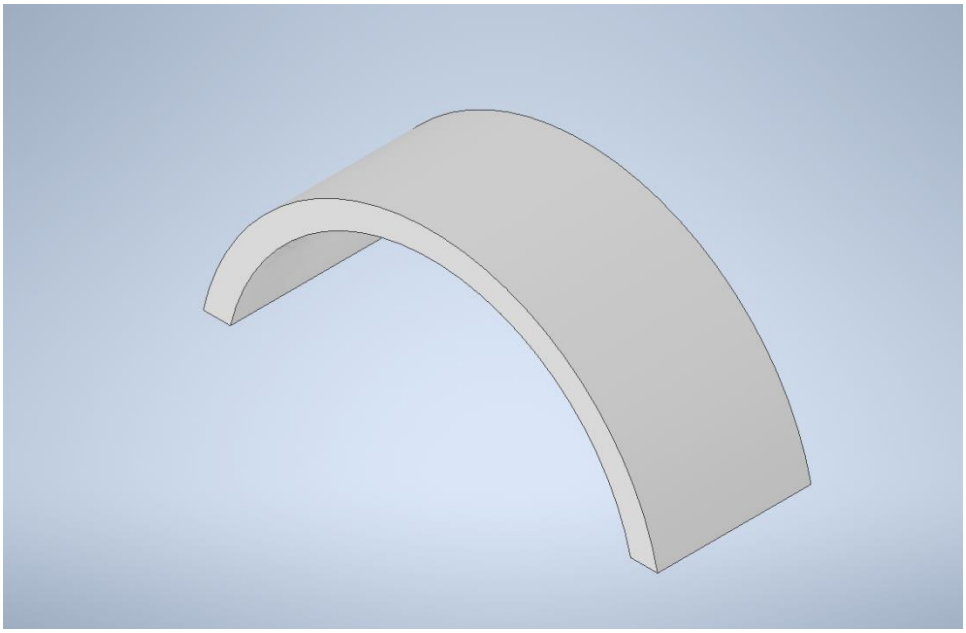


Figure 44. Handle attached to the top of slicer attachment

Modelling: Engineering Drawings

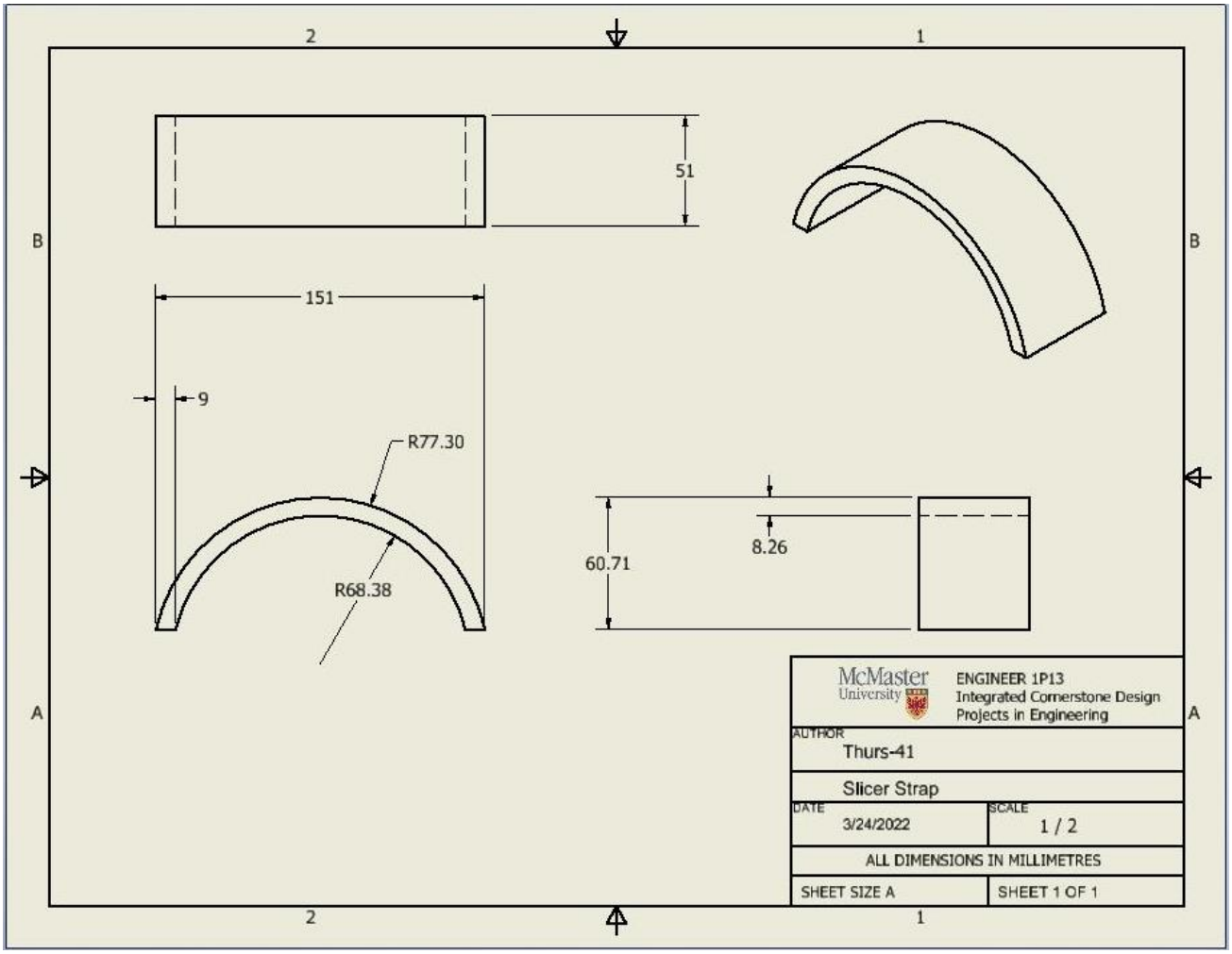


Figure 45. Engineering Drawing of Slicer Strap

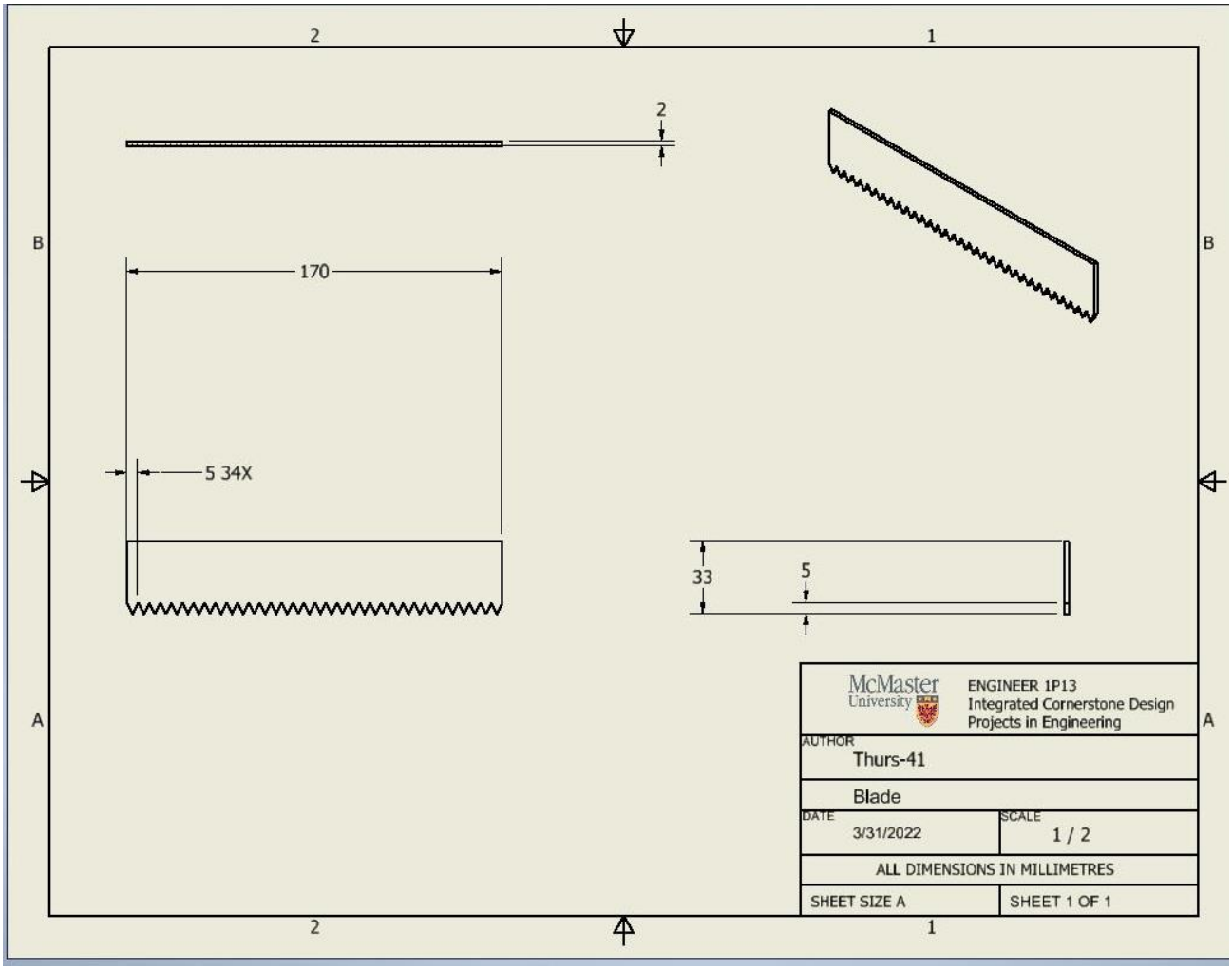


Figure 46. Engineering Drawing of Blades

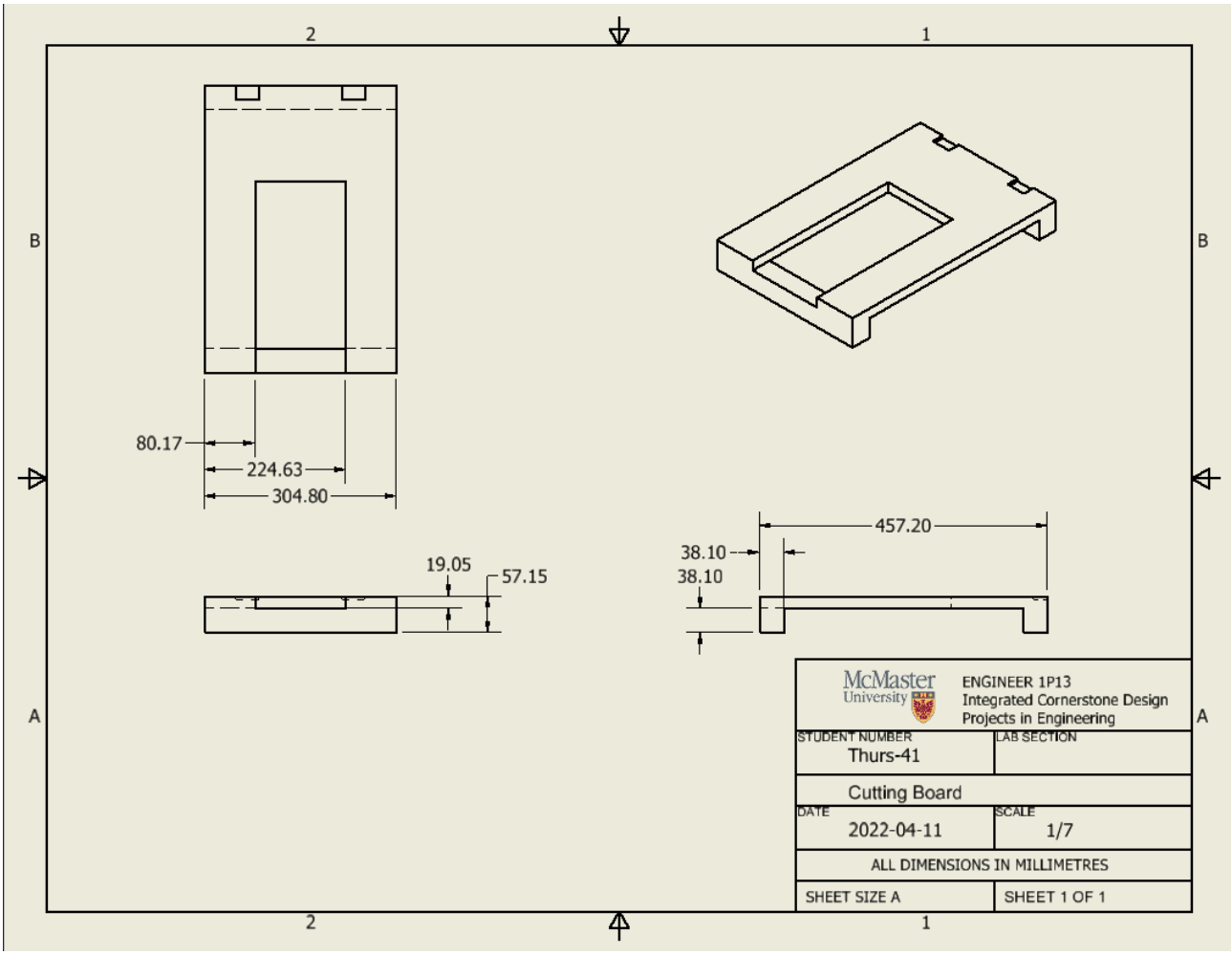


Figure 47. Engineering Drawing of Cutting Board

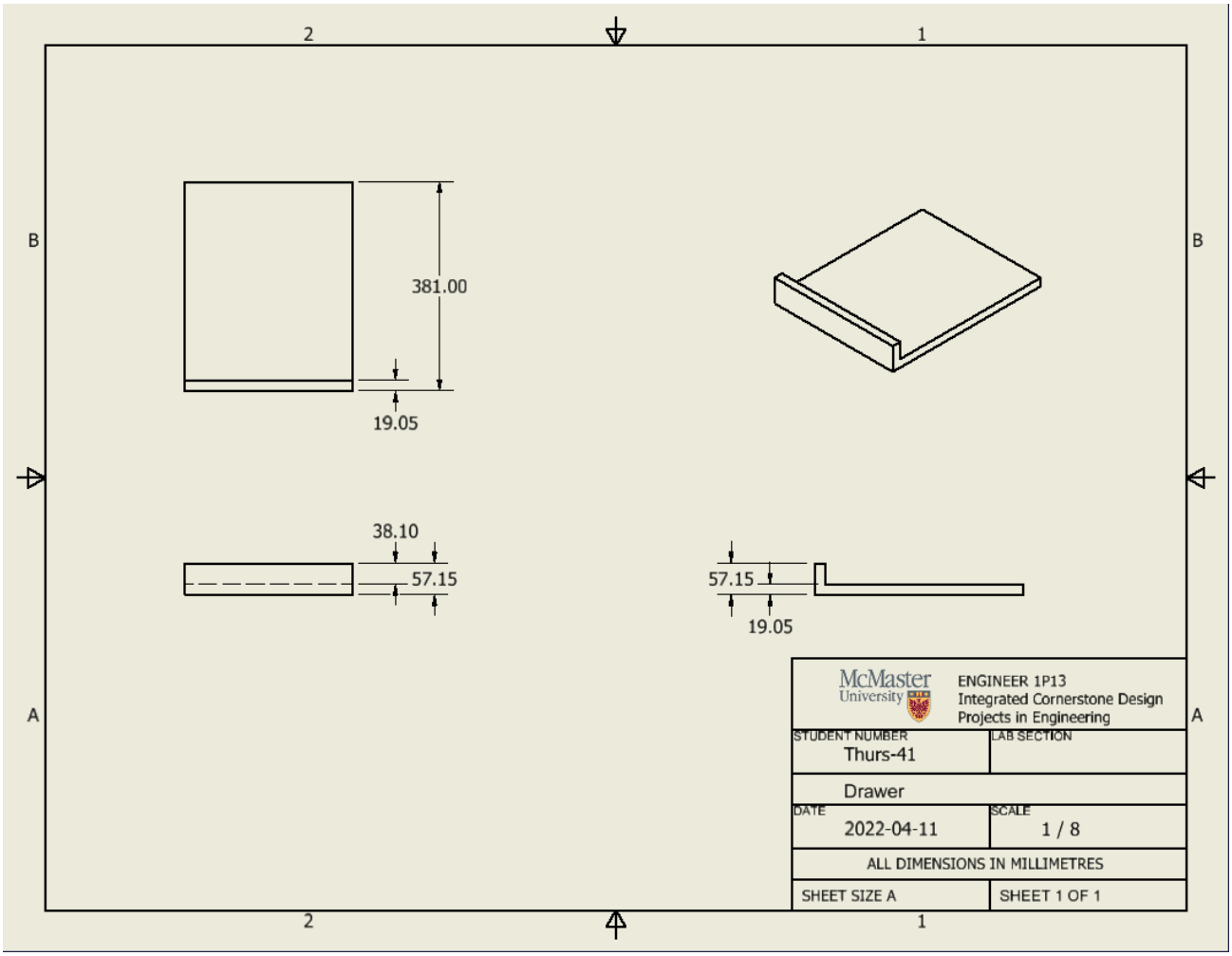


Figure 48. Engineering Drawing of Drawer

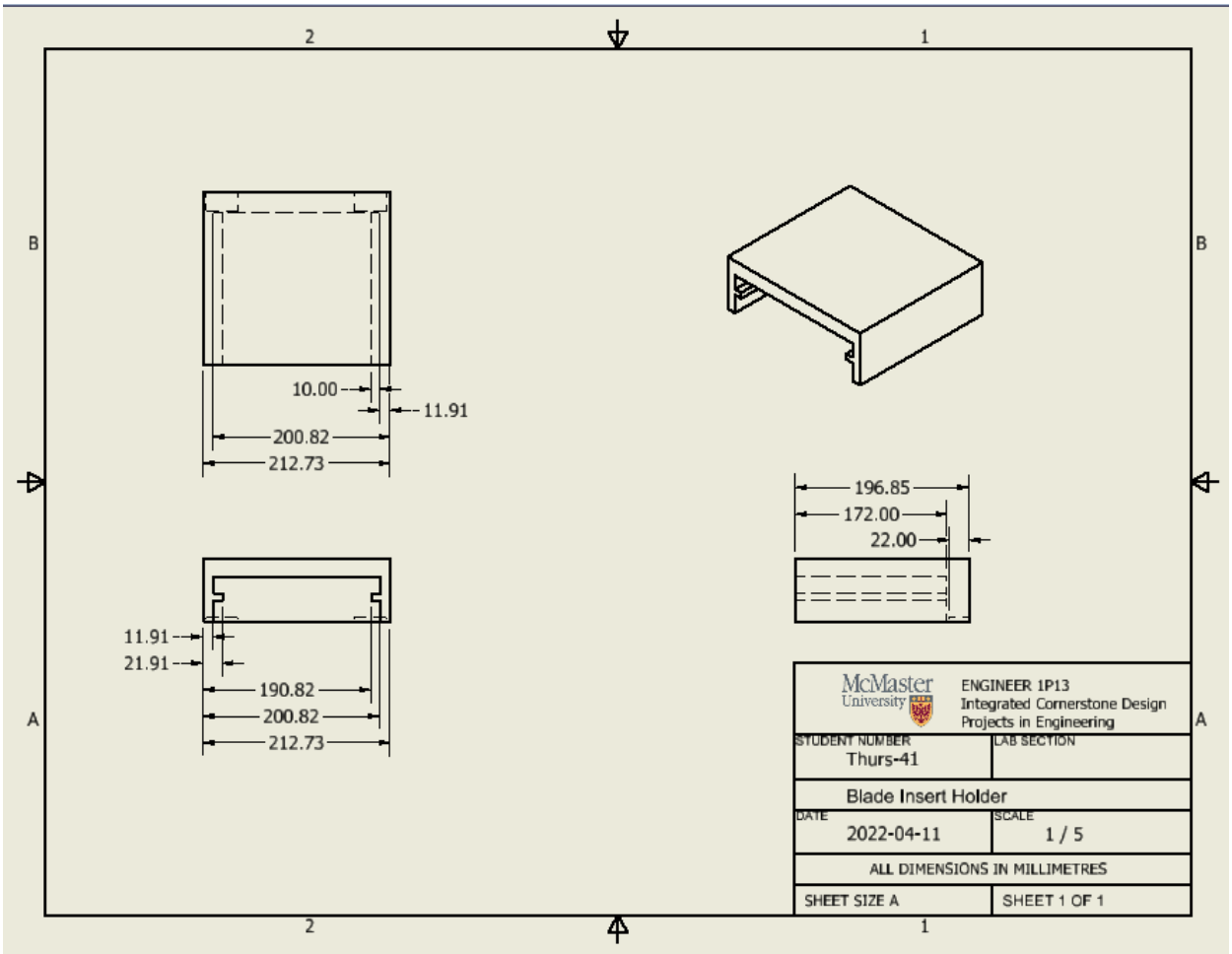


Figure 49. Engineering Drawing of Blade Insert Holder

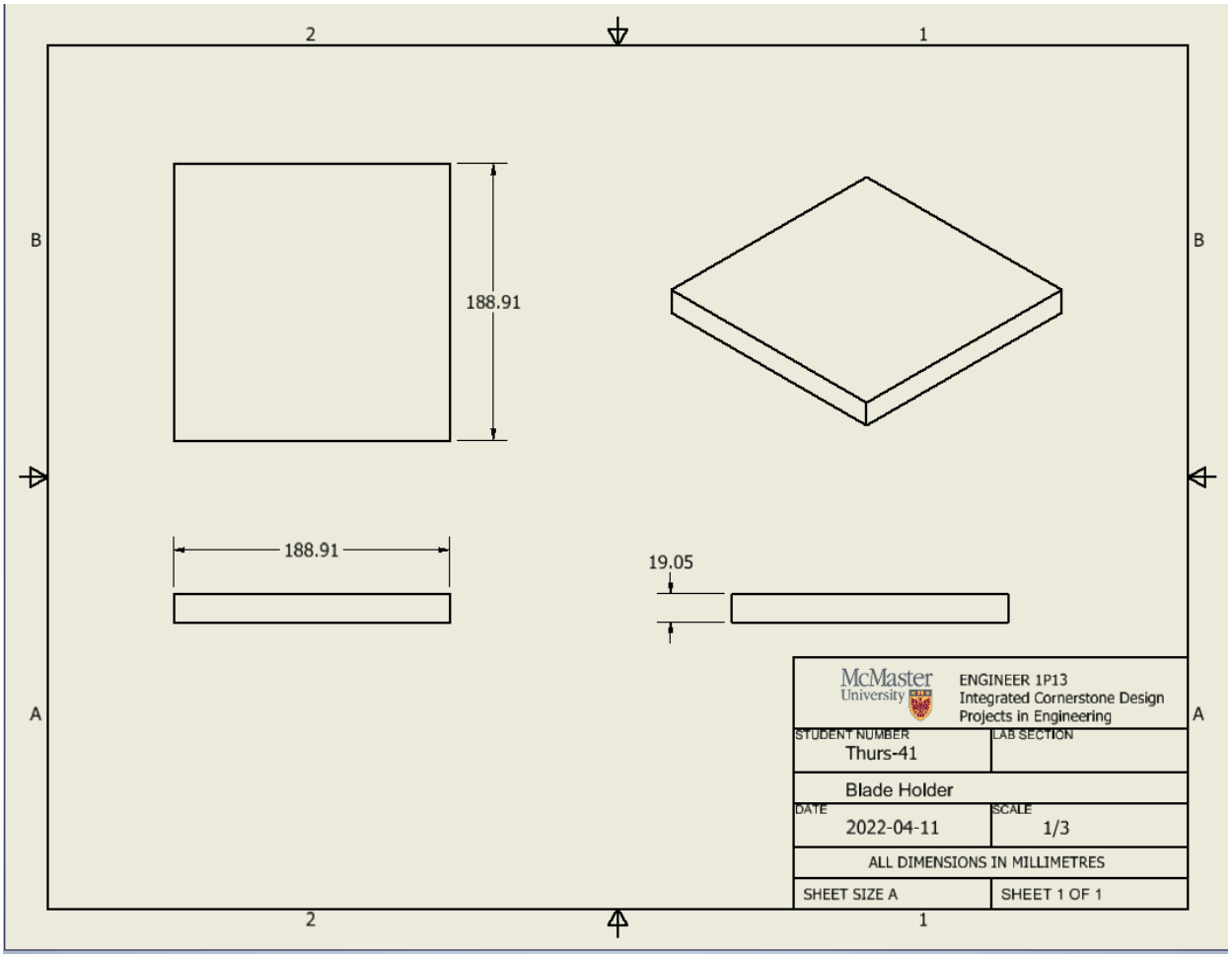


Figure 50. Engineering Drawing of Blade Holder

Appendix B – Project Schedule

Preliminary Gantt Chart

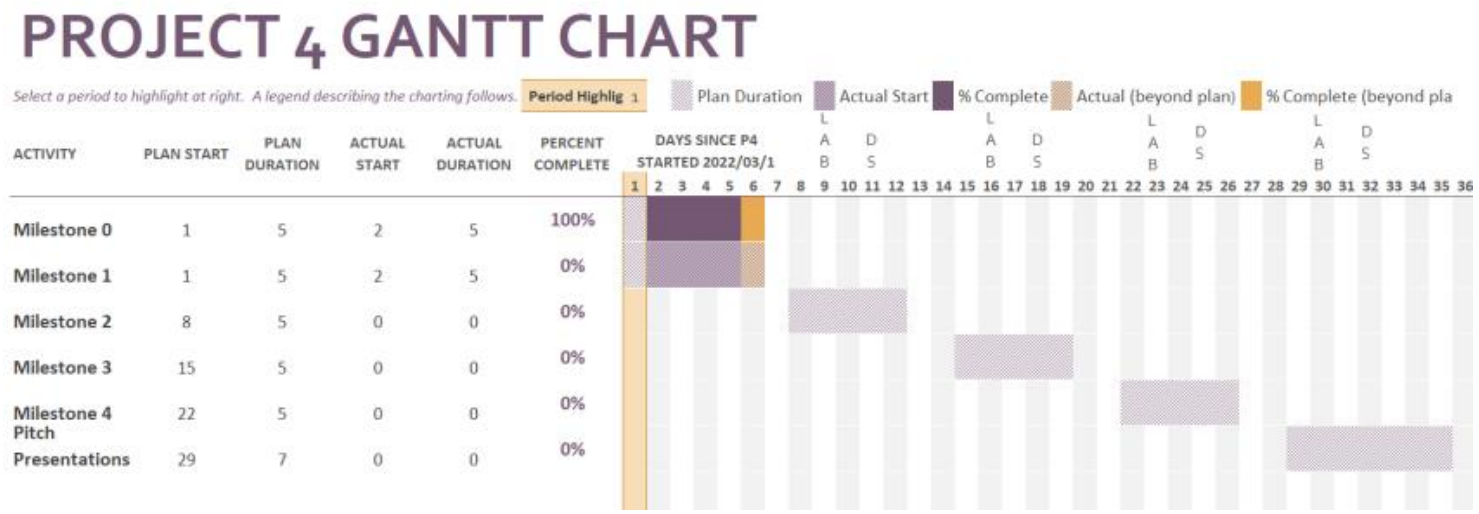


Figure 51. Preliminary Gantt Chart

Final Gantt Chart

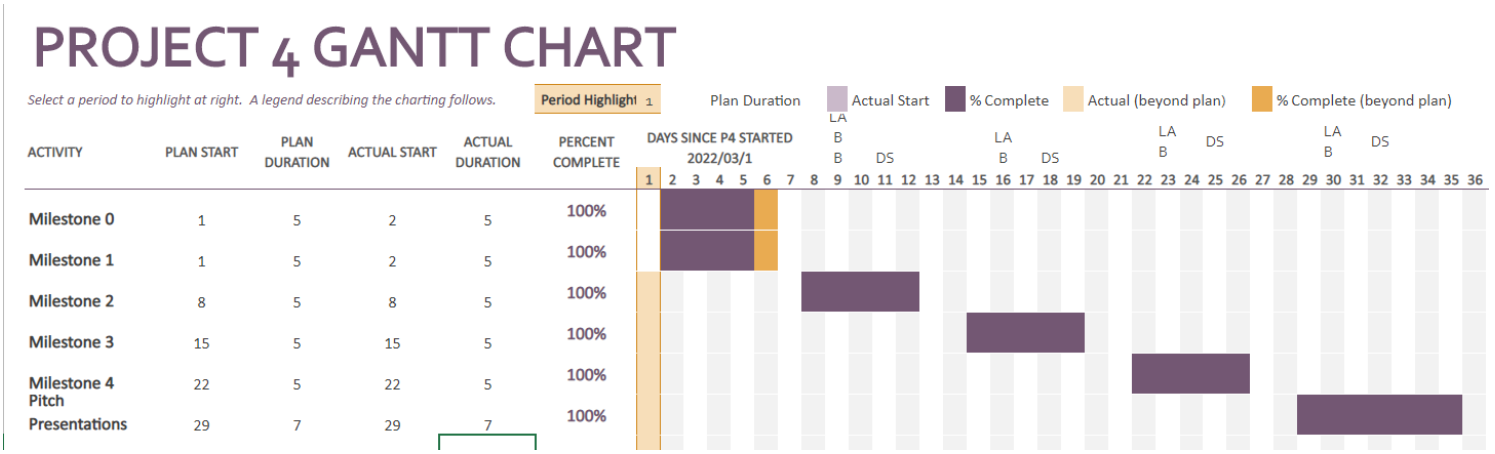


Figure 52. Final Gantt Chart

Logbook of Additional Meetings and Discussions

Date	Communication Type	Time	Location	Members present	Topic	Notes
3/1/22	Meeting	11:30 am – 12:00 pm	ETB-125	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 0&1	-completed the client notes -finished up milestones
3/5/22	Discussion	7:00 pm – 7:30 pm	Microsoft Teams	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 0&1	-packed up the milestones -discussed plans about the design
3/8/22	Discussion	11:30 am – 12:00 pm	ETB-125	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 2	-finished second client note -wrote the refined problem statement
3/10/22	Meeting	2:00 pm – 3:30 pm	ABB-C419	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 2	-thought about the initial prototype of the design
3/15/22	Discussion	11:30 am – 12:00 pm	ETB-125	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 3	-finished the initial prototype -completed decision matrix
3/17/22	Meeting	2:00 pm – 3:30 pm	ABB-C419	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 3	-participated in the design review -talked about how to fix the problems with blades and boards
3/22/22	Discussion	11:30 am – 12:00 pm	ETB-125	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 4	-made a test plan -refined the initial prototype
3/24/22	Meeting	2:00 pm – 3:30 pm	ABB-C419	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Milestone 4	-participated in the second design review -gained feedbacks -refined prototype
3/19/22	Discussion	11:30 am – 12:00 pm	ETB-125	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Design refinement	-discussed about some specific dimensions
3/31/22	Meeting	2:00 pm – 3:30 pm	ABB-C419	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Design refinement	-created a solid model of the design -decided which component requires 3D printing
4/5/22	Meeting	3:00 pm – 4:00 pm	PGCLL	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Final preparation	-assigned the parts for presentation -discussed about future refinements of the design
4/6/22	Meeting	8:30 pm – 9:00 pm	Microsoft teams	Louisa Mueller, Muhammad Khan,	Video recording	-recorded the video before presentation

				Wendong Wang, Marisa Patel		-finished up presentation PowerPoint
4/7/22	Presentation Prep	3:50 pm – 4:30 pm	ABB-C419	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Final presentation	-final presentation
4/11/22	Meeting	7:00 pm – 7:30 pm	Microsoft teams	Louisa Mueller, Muhammad Khan, Wendong Wang, Marisa Patel	Final deliverables pack up	-packed up the final deliverables

Appendix C – Weekly Meetings

Weekly Design Studio Agendas and Meeting Minutes

Tuesday March 1, 2022:

1. **Attendance and Updates**
- Everyone is present
- First met of the team
- Introduction to the project

1. **Meeting Minutes and Milestone Work (Milestone 0&1)**
- Completion of client notes
- Finish the initial problem statement
- Use the objective tree to demonstrate the requirements of the client
- Determine the three main objectives: ergonomic, lightweight, adaptive
- Collect the abilities of each team members to use specific skills to deal with the problem

1. **To be done after class**
- Complete the Gantt chart and client notes

1. **Notes for next week**
- Focus on the research assignment next week

Tuesday, Thursday March 8, 10, 2022:

1. **Attendance and Updates**
- Everyone is present
- Start work on sketches
- Ask help for final function for morph chart

1. **Meeting Minutes and Milestone Work (Milestone 2)**
- 1. Finish the compiled second client notes
- 2. Determine the specific target – cutting with a knife
- 3. Finish the individual research assignments
- 4. Finish the functional analysis
- 5. Complete the refined problem statement
- 6. Explore more concepts and sketch them

1. **To be done after class**
- Complete the initial prototype of the design.

1. **Notes for next week**
- There will be design reviews from science students on Thursday to give feedback to our designs.

Tuesday, Thursday March 15, 17 2022

1. **Attendance and Updates**

- Everyone is present

1. **Meeting Minutes and Milestone Work (Milestone 3)**

- 1. Finish the initial prototype of the designs
- 2. discuss and collect pros and cons of the designs
- 3. complete the decision matrix
- 4. Finish the design interview from the science students and gain feedback
- 5. decide on the materials of the designs (filament of 3D printing – 0.2 mm PLA – quite food-safe)
- 6. think about ways to remove the knife after cutting stuff
- 7. Need to think about the positions, size and alignment of the blades of concept 2.
- 8. Methods to clean the boards and blades.

1. **To be done after class**

- Come up with the resolutions corresponding to the feedback

1. **Notes for next week**

- Pick one concept to work on next week

Tuesday, Thursday March 22, 24 2022

1. **Attendance and Updates**

- Everyone is present

1. **Meeting Minutes and Milestone Work (Milestone 4)**

- 1. Refine the initial prototype
- 2. Build the actual physical design
- 3. Make a test plan
- 4. In the design review, ask for feedback for the refined design
- 5. Review of the design:
- 1) make some kind of button instead of pulling the blades out
- 2) suction or gravity (how the board is fixed on the table (rubber dots, etc.)
- 3) all the food will remain under the blade after cutting
- 4) The design is useful for the client
- 5) the client needs to lift the board up to get the food slices after cutting them.
- 6) make the board higher from the table
- 7) the container can be designed to slide in or out
- 8) easy to cut himself when putting the blade in or out. (find an easy way to pull them out)
- 9) find ways to prevent the client from getting hurt
- 10) figure out the dimensions of the blades and board
- 11) The client has finger dislocation problems so when sliding the blades he might hurt himself.
- 12) The dimensions (height) of the board might cause issues to the client's elbows and shoulders (the elbows cannot be positioned too high – or can rest)

1. **To be done after class**

- Finish the milestone 4 worksheet
- Refine the prototype

1. **Notes for next week**

- Refine the prototype and figure out the blade problem

Tuesday, Thursday March 29, 31 2022

1. **Attendance and Updates**

- Everyone is present

1. **Meeting Minutes and Milestone Work**
- 1. Refined the design and discussed some specific dimensions
- 2. Focusing on the report
- 3. Prepare for the pitch presentation
- 4. Made sure that only blades needs 3D printing
-
1. **To be done after class**
- Create a solid model for the design
1. **Notes for next week**
- Discuss about the final deliverable and pitch interview
- Refine the final prototype and create a solid model

Tuesday April 5, 2022

1. **Attendance and updates**
    a. Everyone is present
1. **Meeting minutes**
    a. Completed the PowerPoint for presentation
    a. Completed the final deliverables
    a. Assigned the presentation parts
    a. Discussed about the improvements of the design
1. **Updates**
    a.

Wednesday April 6, 2022

1. **Attendance and updates**
    a. Everyone is present
1. **Meeting minutes**
    a. Finished recording the video for demonstration
1. **Updates**
    a. none

Monday April 11, 2022

1. Attendance and Updates
- Everyone is present

2. Meeting Minutes and Milestone Work
- 1. Packing up the final deliverables

1. **To be done after class**
- None
1. **Notes for next week**
- None

Appendix D – Worksheets

Milestone 0 Team

ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR: MILESTONE 0 – COVER PAGE

Team Number: Thurs-41

ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 0 – TEAM CHARTER

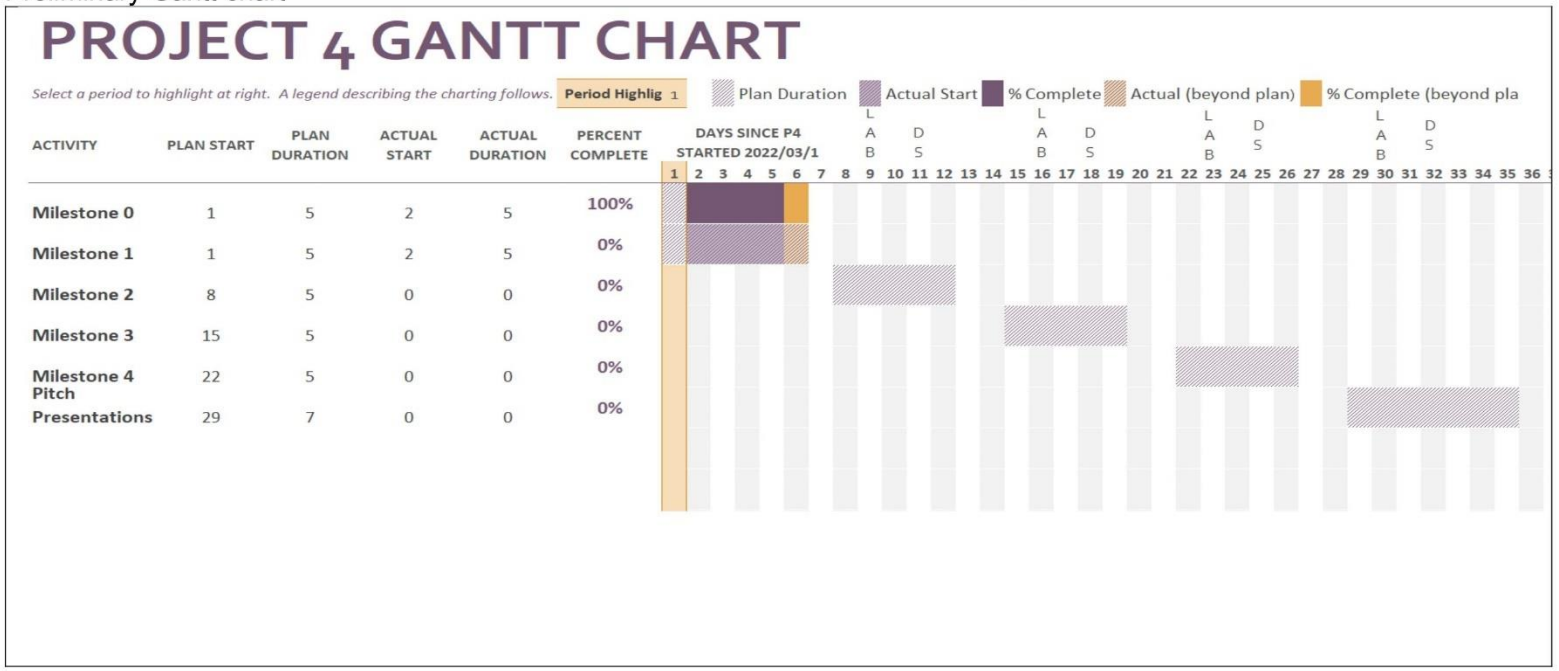
Team Number: Thurs-41

MILESTONE 0 – PRELIMINARY GANTT CHART (TEAM MANAGER ONLY)

Team Number: Thurs-41

Full Name of Team Manager:	MacID:
Muhammad Umar Khan	khanm417

Preliminary Gantt chart



ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR: MILESTONE 1 – COVER PAGE

Team Number: Thurs-41

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Louisa Mueller	muellel
Marisa Patel	patem156
Wendong Wang	wangw198
Muhammad Umar Khan	khanm417

ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 1.1 – CLIENT NOTES

Team Number: Thurs-41

You should have already completed this task individually prior to Design Studio/Lab for Week 7.

1. Copy-and-paste each team member's client notes on the following pages (1 team member per page)
   → Be sure to indicate each team member's Name and MacID

We are asking that you submit your work on both the team and individual worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit their client notes with the **Milestone One Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone One Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing the rest of the milestone

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Louisa Mueller	MacID: muellel

Copy-and-paste the notes from the introductory client visit for one team member in the space below.

- Undiagnosed learning disability, found out at 17
- Represents people with disabilities for City of Hamilton
- Ehlers-Danlos Syndrome, genetic disorder that affects collagen (body glue that holds everything together)
- Affects a lot of joints, easily dislocated or subluxation (partially), organs and digestion as well
- Hernias, ulcers, early form of emphysema (micro scarring on lungs)
- Unable to lie down
- Potential ideas: no bracing, needs to be ergonomic
    - Exercise equipment (isolating and strengthening without putting too much strain)
        - Shoulders, legs, hips, hands
    - Adaptive devices (ways to reduce strain)
        - Cushioning joints and reducing lateral movement
    - Working in the kitchen (small portable device)
    - Doing maintenance (used to really enjoy this)
    - Cleaning (drops things a lot)
    - Working on a computer (typing, using the mouse, proper posture)
        - Voice control does not work
    - The Hallway Project
        - Mounting handles on the wall (wall not properly braced so keep in mind)
    - The Throne (surrounded by pillows on couch, most comfortable here)
    - The Game Shelf (way to play board games without so much pain, misses this the most)

3 Project-4

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Muhammad Umar Khan	MacID: khanm417

Copy-and-paste the notes from the introductory client visit for one team member in the space below.

1. *About them*
- *42 years old*
- *Undiagnosed Learning disability when he was 17*
- *Worked in trades*
- *Got injured a lot*
- *Worked in Shipping and receiving*
- *Current Status: part of chronic pain management program teaching tai chi, unfortunately cannot do that anymore*
- *Ehlers-Danlos syndrome affects collagen, affects a lot of his joints*
- *Has some co-morbid conditions*
- *Has access to a 3D printer*

2. *Challenges they face*
- *Voice control does not work as he has issues with speech*
- *Legs and knees buckle unpredictably*
- *Hasn't slept lying down in a decade due to his disability*
- *Reaching, grabbing, rolling dice while playing games with his son*

3. *What's important to them*
- *Looking for something that is more ergonomic rather than something that will brace joints and muscles*
- *Devices in the kitchen that can easily be detached for others to use*

4. *Potential Ideas to Improve Quality of Life*
- *Exercise equipment: ways of isolating and strengthening joints without putting too much strain on them while reducing lateral movement (shoulders, legs, hips, hands)*
- *Work around the kitchen: cutting, washing, mixing, pouring, shaking, blending, straining, sifting, holding dishes etc*
- *Maintenance: cutting, drilling, sawing, screwing*
- *Cleaning: sweeping, mopping, wiping, dusting, spill cleaning*
- *Working on a computer: keyboard key pressure, chair adjustment*
- *Hallway project: mounting handholds to help aid client navigate his hallways*
- *Modifications to his wheelchair*

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Marisa Patel	MacID: patem156

Copy-and-paste the notes from the introductory client visit for one team member in the space below.

Client Background

- Name: James, Age: 42
- Had an undiagnosed learning disability which was not determined until the age of 17
- Worked in the trades and construction, moved into shipping and receiving (had to stop)
- Current status:
  - Part of a chronic pain management program teaching Tai Chi to people with disabilities, shut inns in apartment buildings, and seniors (had to stop teaching)
  - Signed up to represent people with disabilities for the city of Hamilton on the Advisory Committee for Persons with Disabilities

Conditions

- Ehlers-Danlos Syndrome
  - A genetic disorder that affects collagen
  - Client's collagen is unpredictable
    - Sometimes it is very brittle or very stretchy
    - When it gets injured, sometimes it heals very quickly but wrong
  - This mostly affects a lot of the clients' joints
    - Almost every one of his joints can dislocate or subluxate
    - Joints are very weak
      - Tend to pop out all the time and gets injured in odd ways
- Invisible Disabilities
  - Can cover physical, social, or mental disabilities
- Co-morbid Conditions
  - Tangentially related to the condition you have
  - Client has Ehlers-Danlos Syndrome and also has a hiatal hernia, a large ulcer, an early form of emphysema that causes micro-scarring on his lungs that's restricted to a connective tissue disorder
- Genetic Mutations
  - Client also has a Factor 5 Leiden mutation (80 times more likely to clot than others)

Possible Ideas to Improve Clients' Quality of Life: Exercise Equipment

- Ways of isolating and strengthening the joints without putting too much strain on them while reducing lateral movement (lateral movement: side to side movement).
- Shoulders
  - Hard for him to exercise them when the movement used to exercise dislocated them
- Legs
  - Uses a wheelchair
  - Walking indoors is not the same as outdoors, treadmills are expensive
- Hips

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    - He is unable to lie down and is usually always standing or sitting
- Hands (main concern)
    - Tried exercise devices including various-shaped grip strengthening devices squeeze balls, squeeze rings, exercise balls, and Chinese balls
        - Strengthens fingers, but the pressure on his palms put the joint out in his hands
        - Round-shaped tools were not evenly squeezing the fingers and bones in the hand properly, causing the joints to pop out
        - Since these rely on lots of lateral movement, his joints would get stuck

Possible Ideas to Improve Client's Quality of Life: Adaptive Devices

- Bracing: Takes over the muscle so it is no longer active, and the brace is doing the work
- Ergonomic: Cushioning the joints and protecting it from sliding out laterally, but still requiring the muscle to do most of the work (this is what the client is looking for)
- Ways of reducing strain while the client carries out day-to-day tasks. This can be done by cushioning the joints and reducing lateral movement or sudden strain.
- Working in the Kitchen
    - Cutting, washing, mixing, pouring, shaking, blending, straining, sifting, holding dishes, etc.
    - Tool that can be unattached instead of completely adapting the kitchen to his needs
- Doing Maintenance
    - Cutting, drilling, screwing, sanding, painting, etc.
    - Clients hands cannot do this kind of work as its very violent on his joints
- Cleaning
    - Sweeping, mopping, wiping, dusting, spill cleaning, vacuuming, etc.
- Working on a Computer
    - Typing, using the mouse, maintaining the proper posture
    - Pressure to press down on the keys, joints slipping out laterally when moving along the keyboard, loss of feeling in fingertips (nerve damage), the positions to sit in for longer times, mouse causing nerves to pinch/go numb, and straining his neck and shoulders
    - Avoids voice control as he has TM joints that come out and has lost most of his teeth

Possible Ideas to Improve Client's Quality of Life: The Hallway Project

- Legs and knees buckle unpredictably often, causing him to fall
- In the hallways, there is nothing for him to hold on to
    - Walls are built out of metal studs and don't have bracing rods for handrails. Find ways of mounting handholds that spread the weight over a large distance

Client's Wishes

- The Throne: Sleeping lying down
    - Spine and shoulders have not let him sleep lying down for more than a decade
    - Sleeps in the living room surrounded by pillows to take the weight off his shoulders and upper back, and uses a cushion to prop up legs
- The Game Shelf: Wishes to play more games with his son
    - Finding ways of playing board games by manipulating things without straining
- 3D Printing: Find a way to modify using a 3D printer
    - Created a grocery bag handle which provided relief for his finger joints
    - Created a wheelchair knob with three different control surfaces on it
    - Created a gripper to reach things on high shelves with a hook

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Wendong Wang	MacID: wangw198

Copy-and-paste the notes from the introductory client visit for one team member in the space below.

42 Years old

Found out at 17

Connective tissue disorder

Collagen is mutated and does not behave according to norms.

Joints can dislocate and subluxate.

Comorbid condition: kyphoscoliosis-curvature of the spinal cord is in opposing directions

Possible ideas:

Exercise equipment-special designed for the knees. Isolating and strengthening the joints (Shoulders, legs, hips, hands, etc) *a place to rest

Adaptive devices- ergonomic, reducing bracing: reduce strain while carrying out daily tasks. (e.g cushioning the joints and reducing lateral movement or sudden strain) (atrophying muscle)

Working in Kitchen: Cutting, Washing, Mixing, Pouring, etc

Doing Maintenance: Cutting, Drilling, Screwing, Sanding

Cleaning-love cleaning the floor: sweeping, mopping, wiping, dusting, etc.

Using the computer: Time spent on computer is painful - position to operate keyboards is painful and difficult on the hands. (interested in a method that can help him use computer for a longer time)

Voice controls not working; typing, using the mouse, maintaining the proper posture

Hallway Project-collapsing: Handrail(need to reengineer the entire wall)- Requires a handhold: easy to install (random handhold along the hallway)

Wants to do wind surfing, jogging, parachuting, biking, etc.

Sleep in the same bed with wife- Unable to sleep lying down – a method that helps him to sleep more comfortably. (voice control is not working)

Game shelf: Play games with his son- painful to reach for the small pieces in the board games.

3D printing experience: like building things with the 3D printer; Built a grocery bag handle-spread the weight out of the fingers

Control handles for wheelchair (different designs)

Grabbers are too big to carry(modified)

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ENGINEER 1P13 – Project Four: *Power in Community*

Made a fender for the wheelchair
Idea; Program- take the photos – being able to put the tool together- easier to modify for the client
Cannot pour the tea out of the pot
Price - inexpensive

*If you are in a team of 5, please copy and paste the above on a new page.

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MILESTONE 1.2 – INITIAL PROBLEM STATEMENT

Team Number: Thurs-41

1. As a team, come up with an initial problem statement and include it in the space below.
   - → Make use of your client notes to define your primary function
   - → Remember to avoid solution-specific statements
     - Focus on what your design *should* do for the client in a general sense (not *how* to do it)

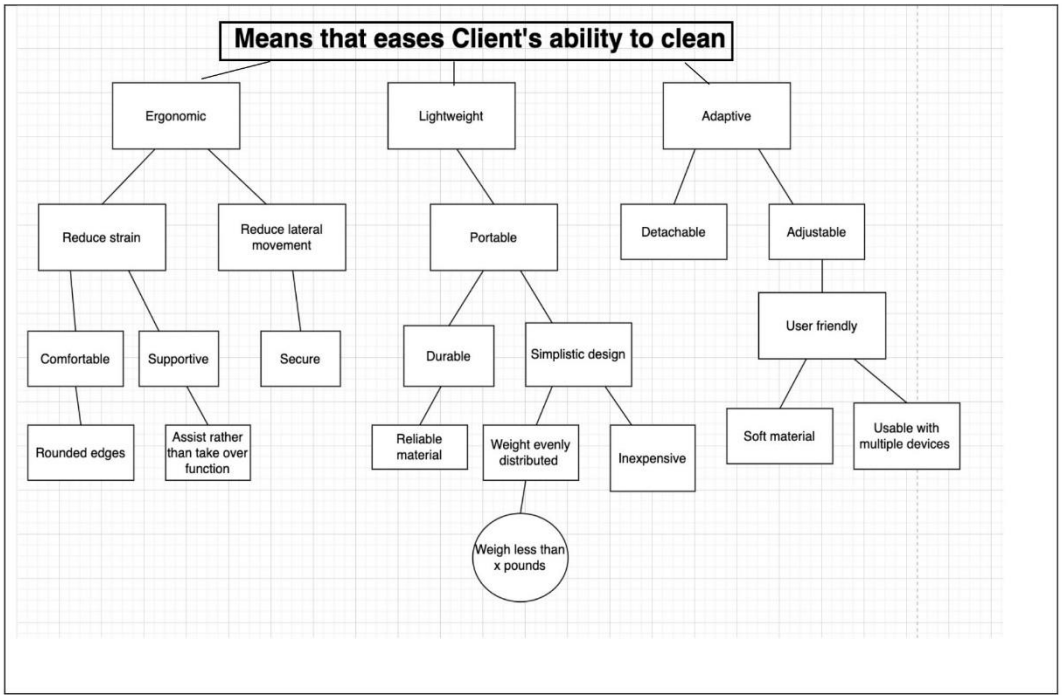
Design a means that makes the client's day-to-day tasks, such as cleaning, easier to do, without causing physical strain on his joints.

ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 1.3 – OBJECTIVE TREE, HOW/WHY LADDER, METRICS

Team Number: Thurs-41

1. As a team, use an objective tree and/or How/Why ladder, to refine and guide the focus of the project.
   → If your team chooses to do both, copy and paste the blank box on a separate page
   → Your diagram(s) can be hand-drawn or done on a computer. Please make sure it's well organized and ***readable***.
2. If you need to see examples of each tool see "Review of Design Process" lecture – Wednesday, Feb 24th.



Justify your team's reasoning behind the choice of design tool(s):

The reason why we used the objective tree is that it can clearly demonstrate the requirements and factors involved in the design. The relationship between each factor can also be perfectly shown which makes the different components of this design understandable. It concludes the different objectives into single words so that the purposes and progress can be easily determined. We decided not to use a How/Why ladder because for our purposes, designing the means is our main

goal and that tool is more applicable to the reasoning behind our design rather than actions we can take to produce a prototype. Although both are important, we decided the objective tree would be more helpful in the long run during this project.

1. What are your top objectives (in no particular order)?

Ergonomic
Lightweight
Adaptive

2. What is your rationale for selecting each of these objectives? Write maximum 100 words for each objective.

Objective 1: Ergonomic

Rationale: The design should be ergonomic. This is because it should provide cushioning to the client's joints and provide protection for the joints. This will help prevent the joints from sliding out laterally. This will also still require the client's muscles to do the majority of the work, which is what is desired.

Objective 2: Lightweight

Rationale: The design should be light in weight so that the client can carry and utilize it easily without adding more pain and strain to the client's joints. A lightweight design will also ensure that less pressure and weight is being applied to the client's joints.

Objective 3: Adaptive

Rationale: The design should be adaptive. This is because the means should be designed such that it can be used for several sized and shaped objects. This will ensure the client can carry out various day-to-day tasks.

3. Fill out the table below with associated metrics (including units) for each objective.
Remember: Metrics should be something you can actually test or measure as part of your process (e.g., calculate weight of a part by iProperties in CAD, test results of a physical prototype).

Objective:	Ergonomic
Unit/Metric:	Assess the risk/injury factors of the prototype (Rate of risk/injury)

Objective:	Lightweight
Unit/Metric:	Estimate weight of prototype (Kilograms, kg)

Objective:	Adaptive
Unit/Metric:	Test results of physical prototype with multiple objects (Rate of adaptivity)

ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 1.4 – PROJECT PLAN

Team Number: Thurs-41

1. As a team, outline a project plan where you:
   - → Include a few sentences describing each team member's prior experience with physical and/or software prototyping
     - From previous projects in the course, or any other relevant experience
   - → Compile a list of potentially useful resources, materials, and/or tools for prototyping

   Reminders:

   - → The prototype can be either physical (e.g., cardboard and tape, 3D printed), digital (e.g., Inventor simulation or rendering), software (e.g., code for Raspberry Pi) or some combination of physical, digital and software
   - → Keep in mind that there are no ENG 1P13 physical prototyping resources available to you because we are learning online, which is why we are asking you to take inventory of how you might accomplish prototyping as a group
   - → As you think about how to prototype, remember that you will eventually need to validate your work somehow. Your validation approach will depend on what prototyping technique you use. Examples of validation approaches include (but are not limited to): hand calculation, physical test, software demonstration or simulation.

Useful Resources

- Materials (cardboard, Velcro, tape): These can be used to fabricate a physical model which can be useful to test prototypes' functionality in the real world.
- Autodesk Inventor: Software like Autodesk Inventor can be useful to create an idea and visualize how it should look/how you want a prototype to look.
- Power tools: These tools can help put together parts and help with fabrication in the real world.
- 3D printing: 3D printing allows for another method of fabrication in the real world, but it could take a longer time to do.
- Laser cutting: This is another means to fabricate something that could be more flat.

Prior Experience

- Louisa: I have lots of experience with physical prototyping as I took a design class in high school where I made prototypes of many objects, such as cardboard airplanes, trophies, and cornhole boards. I also worked in a factory one summer using many mechanical tools such as saws, drills and lug machines. I would feel comfortable operating tools if necessary for our final prototype for this project.
- Wendong: I have completed a variety of designs in high school including a full-functioning wave tank, calorimeter, and a water-cooling air conditioner. I am also good at modeling.

- Marisa: I have gained experience in physical prototyping using software such as Autodesk Inventor. I have also had experience using 3D printers and applying a model in a physical environment.
- Umar: I have experience with inventor and 3D printing through course work. I have also done some physical prototyping throughout clubs and some course work in high school.

Milestone 2 Team

ENGINEER 1P13 – Project Four: ***Power in Community***

PROJECT FOUR: MILESTONE 2 – COVER PAGE

Team Number: Thurs-41

Please list full names and MacID's of all *present* Team Members.

Full Name:	MacID:
Louisa Mueller	muellel
Wendong Wang	wangw198
Muhammad Khan	khanm417
Marisa Patel	patem156

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ENGINEER 1P13 – Project Four: ***Power in Community***

MILESTONE 2.1 – CLIENT NOTES

Team Number: Thurs-41

You should have already completed this task individually prior to Design Studio/Lab B for Week 8.

1. Compile your team's notes from the client Q&A visit.

Questions to ask James:

- Info about his hands
- Hand size
- Are you right or left-handed?
- Ask him to pick something up
- Range of motion for hands
- Are you comfortable with Velcro/tightening straps?

Louisa Mueller:

- Uses PLA for 3D printer filament
- Every aspect of using the computer is difficult (mouse especially)
    - Using keyboard requires a lot of lateral movement (uncomfortable)
- Most comfortable keyboard style is laptop style with more low-profile keys and less pressure to push keys
    - However, laptop keyboards are compact which locks the shoulders and upper back
    - Ideally would have a laptop style keyboard with normal keyboard size that could also be portable and move around based on his daily needs and struggles
- Height is 5'10" but can gain and contract depending on the day
- Can lift 30-40 pounds if he is ready for it and having a good day (more about positioning)
- Main issue with using a smartphone is dropping it and smashing the screen, as well as its effect on the shoulder (30-minute limit when using phone)
- Manipulate simple board games such as chess, checkers, card games
- Uses stove and oven most often as well as hand mixer, knives, whisk, spatula in the kitchen
    - Struggles with manual tools (knives, peelers)
    - Loses feeling in hands so worries about not feeling sharp objects
    - Most helpful: knife, cheese grater, whisk
- Translating a lot of weight over a weak area (wall braces)
    - Easy to install
    - Need to displace weight over a large distance
    - Wall is used as a divider
- Stability on the elbow is not a problem, joints never pop out however it gets sore
- Currently uses standard keyboard and mouse with PC
    - Struggles with the amount of time for which he can operate a computer
- Occupational Therapist recommends "breaking the line" (putting leg up on counter when washing the dishes to redistribute weight)
- Medications he uses:
    - Anti-depressant

  - Muscle relaxant (muscle spasms)
  - ADHD
  - Blood clotting disorder
  - Stomach issues (perforated ulcer)
  - Painkillers
- Trackpads are a lateral motion issue
- Repetitive motions/stresses cause loss of feeling in hands or arms (related to constant nerve damage)
  - Changing positions regularly would help
- Not allowed to mop or sweep
- Using pens with soft grip, runny ink (least friction on the pen possible)
- Gripping knife slips out joints in knuckles (finger joints shift to find most optimal position)
- Shoulders (#1) and hands cause most day-to-day trouble (upper body has gone much faster than lower body)
- Doesn't lean back on things unless he's in his throne
- Not being able to fully participate in games takes away from the overall experience
- Lateral movement of the upper body, particularly shoulders, is a problem
- Handle on wheelchair is comfortable position for an extended period
- More traction is preferred with grips and the material they are made from
- Hips and knees are bad and very tender (don't like to move laterally or be bent)
- Stairs are not a problem once the first one has been climbed (sets you up straight)
- Tried a lot of wheelchair assistive devices

Wendong Wang:

- What type of filament when 3d printing: PLA haven't tried ABS, TPU
- Positions computer: don't go on the computer at all when pains happen
- Keyboard design style-comfortable: laptop keyboard – best (doesn't require too much pressure) *halved-can change position(higher or lower) relieve stress of shoulders, ribs
- Height: 5ft10 and a half
- Shoe size: 12 wide or 13 normal
- Weight limit lifting: regular load of groceries up to like 30 pounds (e.g. could not lift up a sausage when bowing and picking it up) – position of arms and muscles while using them
- Hand dimensions: sent on photos
- Part of smartphone not preferred; model of phone presently used: hands are unpredictable; lose feelings when using them- can only afford grey model phones (low income)
- Never tried a drawing tablet
- Specific board games: 23,21,17 years old kids; simple games would be fine
- Kitchen appliance: stove, oven, hand mixer (most often); *food processors, stand mixers- hard to pull out and use them; large bowls are hard to clean – looking for ways to increase efficiency
- Preferred kitchen tasks: cutting, stirring, flipping things, using knives, whisks, spatulas, (wide shoulder motions would cause injury) (cutting things for 10 to 15 minutes)
- Hallway dimensions: more of a structural engineer issue, aluminum studs designed- very weak wall (ripped open the wall and would cause a lot of money) spreading a large amount of weight (at least 100 pounds when falling)
- Does pushing down buttons cause issue: position of hand, wrist band up. When the hand is in the wrist band for a long time it lose feelings; very expensive
- Large movement or small precise difficult: tried armrests but not helpful. The movement of mouse is small

- Handrail: standard or keep handrail low to help walking: not using the handrail walking on the hallway. More for emergency without causing a shoulder damage; height at the lowest portion: 7 ft; solid concrete floor
- Can't use the walker. Shoulder made it impossible to drag a walker; shoulders sag: impossible laying down.
- Activities requiring upper body movement to do small motion
- Games: taxing: handling small pieces or reaching out the pieces across the board- reaching out. *handling small pieces is frustrating.
- Both pillows while sleeping

Muhammad Umar Khan

- What type of filament do you use: PLA
- Shoulder back issues could make it difficult to sit on some days
- Most comfortable keyboard design style: laptop keyboard styles
- Height: 5ft 10 and ½
- Shoe size: 12 wide or 13 regular
- Weight limit using arms: on a good day 30-40 lbs
- Lifting is more about position not weight and if he is ready for it
- Has a 30 min time limit for holding phone
- Most used kitchen appliance: stove, oven, hand mixers, knives, whisk, spatula, peeler
- Repetitive movements cause loss of feeling in hands

Marisa Patel:

- What type of filament do you use with your 3D printer?
    - Mostly PLA
    - Has trouble understanding PETG
        - Sometimes gets the outside layers to bond correctly, but the infill looks very stringy like spaghetti
        - PETG is more durable for kitchen use
- What specific motions, positions, actions are uncomfortable when working at the computer? Mouse design, mouse movement, keyboard layout, the pressure needed to click mouse and keys, etc.
    - All of the above
        - Can depend on the day and the issues being dealt with that day
        - Could be having shoulder/back issues and neck issues which makes it hard to sit in certain positions
        - Hand, elbow, and wrist issues make using the keyboard difficult
        - Mouse is very poorly designed and not suitable for the client
        - Keyboard layout is awkward
            - Hitting the shift key and reaching for another letter restrains the hands
        - Pressure is difficult as too much pressure causes fingers to move
        - Dragging fingers key to key creates a lot of lateral movement
        - Lots of pressure goes to the thoracic spine, shoulder blades, and the collarbone
        - Issues could be more about the chair rather than the keyboard (perhaps elbow supports could help take pressure off of the shoulders)
- What keyboard design styles are the most comfortable in your experience? Which shortcomings do you find most in keyboard designs?
    - Best in terms of pressure and moving the fingers comfortably is a laptop-style keyboard
        - Lower profile keys that don't require much pressure

        - Not too thick keys so its easy to move the hands across the keyboard
        - Issue with this style is that it is designed to be compact, which tenses the upper body and locks the shoulders in a tight position
        - Likes thought of laptop-style keyboard but the size of a regular keyboard, an being able to have both sides of the keyboard in different positions (half on the table, half on his lap)
    - Currently uses a standard PC, standard keyboard, and standard mouse
    - Has problems staying in the same position for large amounts of time (need to break up the line)
    - Trackpads cause lateral movement
    - Repetitive motion is difficult
- What is the clients' height?
    - 5 foot 10 ½
    - Variation in height as the joints can swell, so the height can gain or retract a small amount
- What is the clients shoe size?
    - 12 wide or 13 regular
- Is there a rough weight limit the client can lift using the arms with comfort?
    - If in a proper position, can lift 30-40 pounds
    - Lifting weight is more about being in the proper position than the actual weight of the object
- Measurement of Clients Hands
    - (Avenue file)
- When using a phone, what part of your hands feel discomfort? What model phone do you currently use?
    - Comfort is not a concern, dropping it is a concern
    - Uses gray market phones
        - Has basic functions and inexpensive
    - Currently has a Umidigi phone
    - Shoulders become an issue
    - 30-minute time limit to use a phone
- Does the client have a drawing tablet?
    - No
- What games does the client want to play?
    - Wants to be able to manipulate simple games like chess, checkers, cards
    - Being able to move cards across a table or manipulate pieces
- What kitchen appliances does the client use most often?
    - Knifes, cheese grater, and a whisk cause the most trouble
    - Also uses spatula and hand mixer
    - Losses feelings in his hands, making it dangerous for using tools like knifes
- What restrictions are present regarding mounting objects in the client's hallway?
    - Engineering structural problem
    - Issue is translating a lot of weight over a weak area, which would have to be displaced a large distance (needs to handle at least 100 pounds)
    - Needs to be easy to install
- Medications
    - Antidepressants, muscle relaxants – baclofen, methylphenidate, rivaroxaban, hydromorphone and hydromorph contin
- Discomfort When Using a Knife
    - Position
    - Gripping a knife to cut down causes some finger joints to slip out sideways
    - Find way to reduce the side-to-side movement
    - Need to find a way to distribute the weight of the fingers
    - Reducing the load on the knife and finger placement need to be addressed

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ENGINEER 1P13 – Project Four: ***Power in Community***

MILESTONE 2.2 – RESEARCH ASSIGNMENT

Team Number: Thurs-41

You should have already completed this task individually prior to Design Studio/Lab B for week 8.

1. Copy-and-paste each team member's research assignment on the following pages (1 assignment per page)
   → Be sure to indicate each team member's Name and MacID

See individual worksheet for assignment specification.

We are asking that you submit your work on both the team and individual worksheets. It does seem redundant, but there are valid reasons for this:

1. Each team member needs to submit their research assignment with the **Milestone Two Individual Worksheets** document so that it can be ***graded***
2. Compiling your individual work into this **Milestone Two Team Worksheets** document allows you to readily access your team member's work
   a. This will be especially helpful when completing the rest of the milestone

ENGINEER 1P13 – Project Four: ***Power in Community***

Team Number: Thurs-41

Name: Louisa Mueller	MacID: muellel

Include your research assignment below.

What is your question?

What type of movements trigger joint dislocation in the hands and should be avoided, if possible, for an assistive device addressing hypermobility?

What is your answer?

Many assistive devices are designed to reduce the strain on joints in the fingers and hands for those who are hypermobile [1]. Two concepts to consider when reducing the likelihood of joint dislocation is external and internal pressures [1]. External pressure refers to forces put on our joints when we hold objects that are weirdly shaped or have slick surfaces, as well as when we try to twist something such as a lid that fits firmly [1]. The shape of the device should be comfortable to hold while a grip of some sort may have to be incorporated as well. Internal pressures occur mostly when joints are bent or flexed, which can happen when an object is gripped too tightly or when the hand placement required to use a device is not ergonomically sound [1]. One type of internal pressure to avoid if possible is ulnar deviating pressure, which essentially means pushing the fingers or entire hand away from the thumb [1]. This type of action occurs when pouring a teapot, for example. Putting the hand in this kind of position while using an assistive device is not ideal since it will be causing more strain on the joints and potentially dislocation rather than achieving its intended function, which is the exact opposite. Some strategies to reduce strain on joints in the fingers and hand include widening the grip around an object [2]. This could be achieved by increasing the diameter of an object, lessening the amount of grip required to hold the object and reducing tiredness in the joints [1]. Considerations of unorthodox hand placements when holding a something as simple as a pencil or pen have been seen to work better for hypermobile individuals than the common clasp does [2]. These hand placements work to reduce the usage of the fingertips, resting the shaft between the thumb and index finger and holding the tip between the middle phalanges of the index and third fingers instead [2]. This has shown significant reduction in the pain experienced by individuals with hypermobility in the base of their thumb and index finger [2]. Although ergonomics is a very important consideration to have when designing a new device, new hand placements could be explored if they are comfortable for the user, which is the end goal. Additionally, bending over or slouching to use a device should be avoided as this can cause strain on the upper body as well [1]. Increasing the handle length of a tool reduces the amount of torque, lessening the chances of dislocation or subluxation [1]. This also allows for more core stability and does not involve as much bending or stretching, which would lower chances of further dislocation and other associated injuries [1]. Overall, movements that should be avoided

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are strong grips, ulnar deviation, as well as having to bend the entire body. These can be avoided by widening grips, increasing diameter, as well as increasing handle length.
List of sources:
[1] T. Pelc, "Assistive devices for the hand: Small joint protection," *Hospital for Special Surgery* [Online]. Available: https://www.hss.edu/conditions_assistive-devices-for-the-hand-small-joint-protection.asp. [Accessed: 07-Mar-2022]. [2] H. P. Levy, "Hypermobile Ehlers-Danlos syndrome," *GeneReviews® [Internet]*., 21-Jun-2018. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK1279/. [Accessed: 07-Mar-2022].

ENGINEER 1P13 – Project Four: ***Power in Community***

Team Number: Thurs-41

Name: Wendong Wang	MacID: wangw198

Include your research assignment below.

What is your question?

What are EDS splints and braces? What are the working principles of them and what are their advantages?

What is your answer?

The common symptoms of EDS include joint hypermobility, joint instability, fatigue, skin laxity, etc. People use EDS splints and braces to treat EDS. Those splints and braces are usually used on knees, ankles, wrists, or any other important joints that will cause pain to the client in daily lives and works. The main function of them is to help moving the bones besides target joints. In this case, it can decrease the pressure applied to joints while body parts moving. One typical example is finger splints. They are mostly manufactured by plastic under high temperature. This is an easily affordable option for the clients because the materials are respectively inexpensive. Those plastic materials always have high elasticity and low density. They are usually lightweight so that would not apply more stress to the joints. [1]

Another common advantage of EDS splints and braces is that it can help the patients do physical therapies. The function of splints and braces is to help muscles move instead of fixing the entire body part. In this case, the client is still able to move their arms and legs to prevent muscle atrophy. When the muscles around joints are exercised, the joints are therefore strengthened as well. One functional physical therapy for treating EDS is to let the client exercise in water so that there will be less pressure applied to the patient's joints. The splints and braces are working similarly for them in general environments. Moreover, the cost for professional in-water physical therapy is respectively high. [2]

Another advantage of splints and braces to treat EDS is that they can be customized. People's body part dimensions are not usually the same. Some EDS cases are also found in childhood. Therefore, splints and braces with more dynamic wearing spaces and less expensive prices are more suitable for children and teenagers. More generally, customized splints and braces can help the patients move more easily because the size and dimensions are perfectly designed for a particular client. When they are used in shoulders, knees, ankles, etc., they seem to function in a wide variety of patients in society according to a massive amount of feedback from the customers. This made it possible to help clients by even participating in sports and other manual labor. [3]

Overall, the convenience of EDS splints and braces made it more popular and more commonly used in society. Its low cost and high level of variability (customization) can help the clients enjoy their lives without completely throwing away the common functions of the muscles. In another words, the EDS splints and braces are mostly used for assisting rather than fixing or curing.

List of sources:

[1]"Treating Ehlers-Danlos Syndrome (EDS) Hypermobility." https://www.3pointproducts.com/blog/health-arthritis-finger-and-toe-conditions/treating-ehlers-danlos-syndromeeds-hyperrmobility (accessed Mar. 06, 2022).

[2]"Physical Therapy, Exercise and Braces for People with EDS or HSD Section 1: For Patients".

[3]"Braces for EDS - Just Sparkle." https://justsparklejlm.com/2013/08/braces-for-eds.html (accessed Mar. 06, 2022).

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ENGINEER 1P13 – Project Four: ***Power in Community***

Team Number: Thurs-41

Name: Marisa Patel	MacID: patem156

What is your question?

How does one with joint hypermobility (Ehlers-Danlos syndrome) adapt to grip objects?

What is your answer?

Joint hypermobility is where ones ligaments that hold together joints become weak or loose, which causes joints to move far out of range from the socket [1]. The connective tissue becomes very weak which can cause joints to dislocate and subluxate [1]. Joint hypermobility in the hands makes it very difficult to do simple tasks such as pick up, hold, and grip objects [1]. Joint hypermobility in the hands makes small tasks a challenge due to the possibility of joints slipping out laterally, causing pain and discomfort [1]. Those with hypermobility find ways to improve the joint and muscle strength, but also reduce strain while completing day-to-day activities [1].

When trying to pick up, hold, or grip an object, it is important to ensure that the joint is secured but not fully suppressed as joints can lock in place. It is also important that the joints are being sufficiently supported such that the ability to dislocate and subluxate is evidently minimized [2]. Multiple factors can be considered when deciding how to grip an object or what types of objects are easy to grip. This includes factors such as toughness, shape/material, and the distribution of weight [2]. Hard materials can make gripping objects uncomfortable, locking the joints in place [2]. Rounded or soft-edged objects make it easier for those with hypermobility to hold [2]. Weight is a key factor when picking up an object. Spreading the weight over a certain area helps to ensure that the joints do not endure added pressure, causing them to laterally move [2]. To hold or grip items, provided support is required where an external source can hold the hand in place such as a type of wrap [2]. This allows for the joints to remain in the range of motion they are generally in, rather than slipping out laterally [2]. Minimal rigorous movement will help keep the joints from moving [2]. Wraps used should not be extensively tight as it can cause pain in the hand and cause joints to lock in place and remain stuck [2]. Alternate possibilities that have been used include different types of patterned attachable grips [2]. These grips are typically made of materials like rubber, silicone, or foam [2]. The positioning of the hands can also be very important. Placing hands on the object so they rest flat on the surface allows for more steady control and less strain as it is being supported by the object itself [2]. The placement of the fingers and thumb are also very important. One with joint hypermobility needs to consider where their fingers should go before picking up and holding an object as hyperextension of the fingers can cause joints to laterally move [2]. Holding and gripping objects can take some time as fast-paced movements can also cause joints to move out of place, creating damage and pain [2].

List of sources:

10 Project-4

[1] J. L. Scully, "What is a disease?," *EMBO reports* [Online]. Jul. 2004. Available: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1299105/.

[2] P. Beighton, H. A. Bird, and R. Grahame, *Hypermobility of joints*. New York: Springer, 2012.

ENGINEER 1P13 – Project Four: ***Power in Community***

Team Number: Thurs-41

Name: Muhammad Umar Khan	MacID: khanm417

Include your research assignment below.

What is your question?

How can devices that are engineered to be more ergonomic rather than completely brace one's joints and muscles prove to be more beneficial?

What is your answer?

According to Merriam-Webster, ergonomics, also known as human engineering, is an "applied science" focused on "designing and arranging" objects people use so that the interaction between a person and the object is done in the most efficient and safe manner [1]. In order to fulfil the criteria of a product to be truly ergonomic, the user's anthropometry, workspace design, task and usage as well as human capabilities need to be taken into consideration by the manufacturer or designer [2]. Examples of everyday items that have ergonomic alternatives include ergonomic chairs, mouses, desks and much more.

Braces on the other hand are designed to shift weight away from the damaged area of the specific joint. This further aids in reducing pain and discomfort that one could feel in said area [3]. Braces promote proper function and movement by alleviating the amount of stress and strain that is present on a specific joint [3]. An example of joint braces includes a knee brace that functions by taking away load from the knee joint and placing it on the brace [4]. Due to the stiffness of braces, when an individual is in an upright position, the brace will restrict the knee's range of motion and take weight off the joint [4]. However, constant use of braces can prove to be detrimental to one's joint health. Firstly, there can be great amounts of discomfort associated with the use of a brace [5]. They can feel quite bulky and are prone to slip due to a poor fit, causing further injuries. Additionally, the lack of movement and stress on one's joints can prove to be quite harmful. When one's joints aren't experiencing enough amounts of stress and movement, stiffness in the damaged area can cause conditions to worsen [5].

During the first client visit, James had outlined that he would like the device engineered to be ergonomic rather than brace his joints and muscles. This would allow him to move freely and not experience any restrictions in movement. With that in mind, we must introduce ergonomic devices in his everyday environment.

Simple additions to James' current devices can prove to be quite beneficial in his day-to-day health. An example could be a device that would take away the pressure off his wrists while typing. The addition of supports based off James' anthropometry could alleviate that pressure resulting in a safer and more efficient environment. Additionally, introducing chair cushions based on James' resting position and body could aid in mitigating the stress his neck, back and other parts of his

body could experience. Finally, the use of an angled footrest could also aid James in his tasks that require him to seated. The introduction of this devices would improve his ergonomic alignment and blood circulation.

List of Sources:

[1] "Ergonomics definition & meaning," *Merriam-Webster*. [Online]. Available: https://www.merriam-webster.com/dictionary/ergonomics. [Accessed: 12-Mar-2022].

[2] J. Croasmun, "Is that product ergonomic?," *Sustainable Ergonomics Systems*, 08-Oct-2004. [Online]. Available: https://ergoweb.com/is-that-product-ergonomic/. [Accessed: 12-Mar-2022].

[3] S. D. Jepsen, "Secondary injury prevention: Using braces to reduce joint injuries," *Ohioline*, 08-Nov-2013. [Online]. Available: https://ohioline.osu.edu/factsheet/AEX-982.8#:~:text=Braces%20help%20support%20the%20joint,with%20the%20help%20of%20braces. [Accessed: 12-Mar-2022].

[4] A. Grande, "How knee support works: Focus physiotherapy," *Physiotherapy, Rehabilitation & Sports Injury Clinic*, 12-Mar-2021. [Online]. Available: https://www.focusphysiotherapy.com/how-knee-support-works/#:~:text=When%20a%20person%20puts%20their,joint%2C%20preventing%20a%20recurring%20strain. [Accessed: 12-Mar-2022].

[5] M. C. Staff, "Knee braces for osteoarthritis," *Mayo Clinic*, 20-May-2021. [Online]. Available: https://www.mayoclinic.org/tests-procedures/knee-braces/about/pac-20384791. [Accessed: 12-Mar-2022].

*If you are in a team of 5, please copy and paste the above on a new page.

ENGINEER 1P13 – Project Four: ***Power in Community***

MILESTONE 2.3 – REFINED PROBLEM STATEMENT

Team Number: Thurs-41

1. Write your initial problem statement below. This is what you have submitted for Milestone 1.2.

Design a means that makes the client's day-to-day tasks, such as cleaning, easier to do, without causing physical strain on his joints.

2. Outline the Who, Where, Why, and What elements of your problem statement. Then write the refined problem statement below. Refer to the provided Refined Problem Statement rubric provided.

- Who? – James, our client and target user, who has a connective tissue disorder known as Ehlers-Danlos syndrome.
- Where? – The device will be designed for use in his home.
- Why? – He struggles with daily tasks and experiences a lot of pain doing things such as cooking and cleaning.
- What? – The device should be ergonomic, lightweight, and adaptive so that it can be used with different objects. It should also reduce lateral movement of the hand and strain on the joints that would be experienced without the use of the device.

Refined Problem Statement:

Design an ergonomic means to assist our client, James, who has a connective tissue disorder known as Ehlers-Danlos syndrome which causes him to experience a lot of pain when completing simple daily tasks related to cooking such using a knife. The means will be designed for use in his home to ease the completion of these tasks, which is an essential function. The device should be lightweight and versatile. It should also reduce lateral movement of the hand and strain on the joints that would be experienced without the use of the device.

ENGINEER 1P13 – Project Four: ***Power in Community***

MILESTONE 2.4 – FUNCTIONAL ANALYSIS

Team Number: Thurs-41

1. Include a copy of your team's functional analysis below.

Function	**Means**					
Keep hand flat during motion	Strap	Brace	Wrap	Stabilizer	Platform	Resistive band
Distribute pressure applied by user	Large diameter	Large grip	Rounded edges	Long handle	Extendable handle	Placement of the hand
Restrict excessive movement of wrist while pivoting	Smooth material	Mouldable material	Components fit for client (based on measurements)	Adjustable components	Supports	Angle constraint (when hand is tilted)

ENGINEER 1P13 – Project Four: ***Power in Community***

MILESTONE 2.5 – CONCEPT EXPLORATION

Team Number: Thurs-41

Complete this worksheet during Design Studio/Lab B for Week 8.

1. Include multiple photos of your concept exploration, if needed
   → Include necessary annotations to help in the communication of your ideas
   → Include your Team Number, Name and MacID on *each* concept
2. Insert your photo(s) as a Picture (Insert > Picture > This Device)
3. **Do not include more than *two* concept photos per page**

Make sure to include photos of each team member's concept exploration

We are asking that you submit your work on both the team and individual worksheets. It does seem redundant, but there are valid reasons for this:

- Each team member needs to submit pictures of their concept with the **Milestone Two Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Two Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing the next milestone

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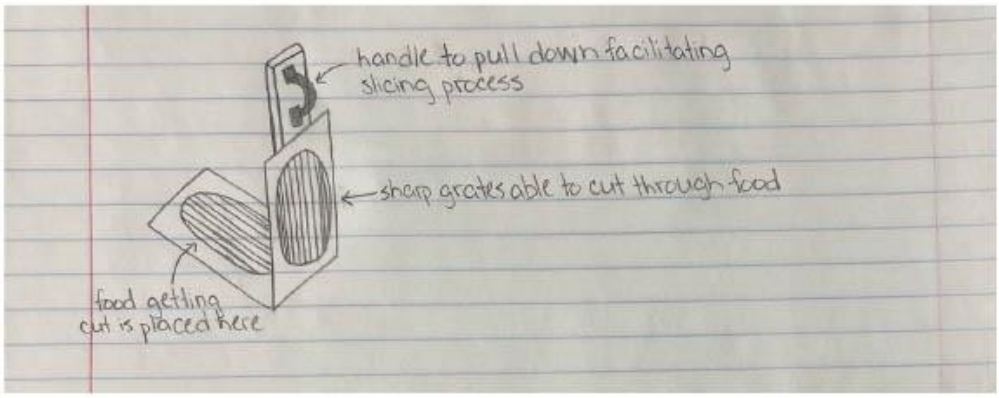
ENGINEER 1P13 – Project Four: ***Power in Community***

Team Number: Thurs-41

Concept 1

Name: Louisa Mueller	MacID: muellel

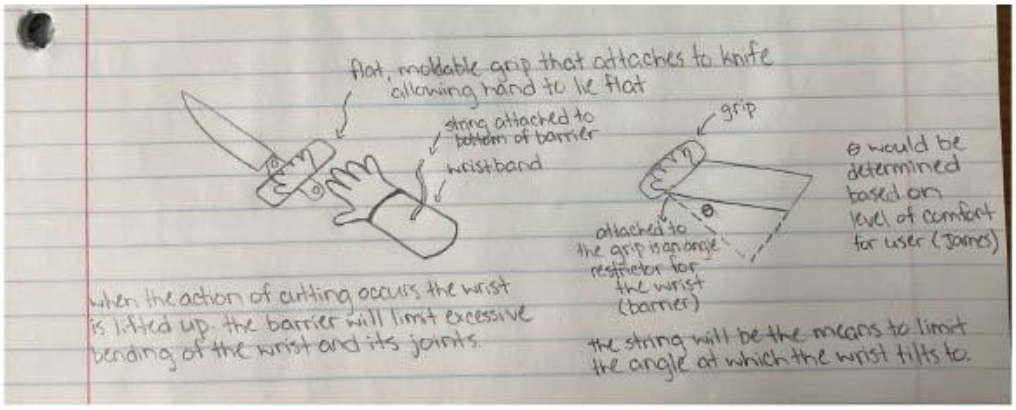
Insert screenshot(s) of your concept below.



Concept 2

Name: Louisa Mueller	MacID: muellel

Insert screenshot(s) of your concept below.



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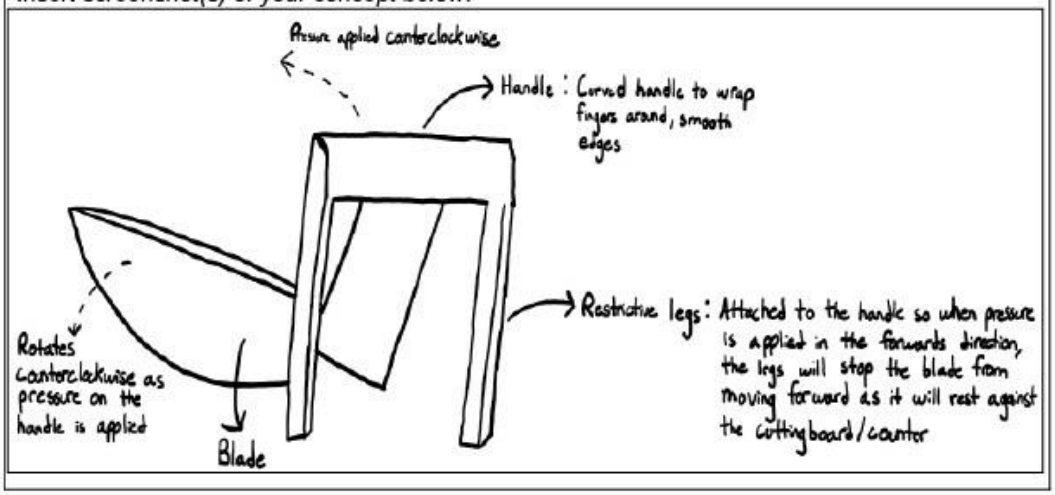
ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Concept 1

Name: Marisa Patel	MacID: patem156

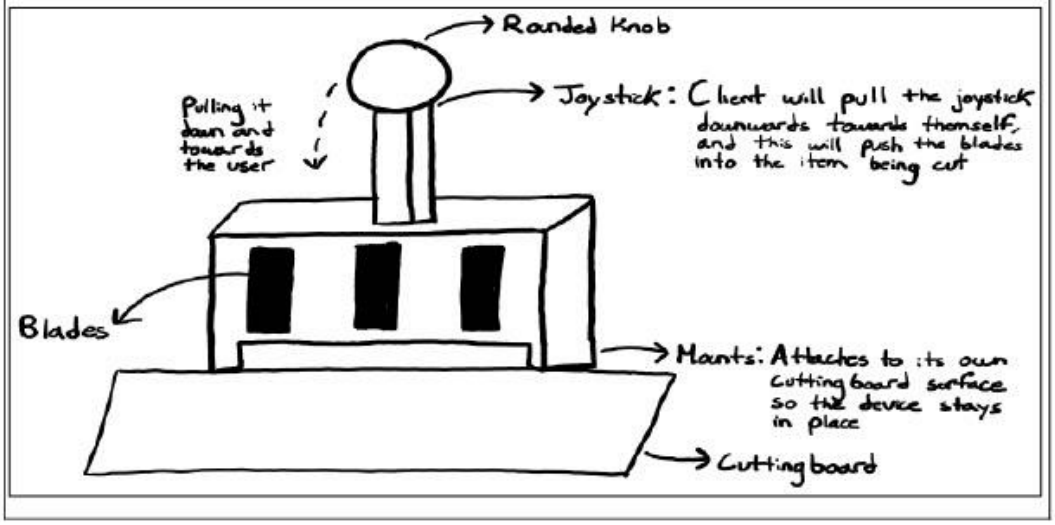
Insert screenshot(s) of your concept below.



Concept 2

Name: Marisa Patel	MacID: patem156

Insert screenshot(s) of your concept below.



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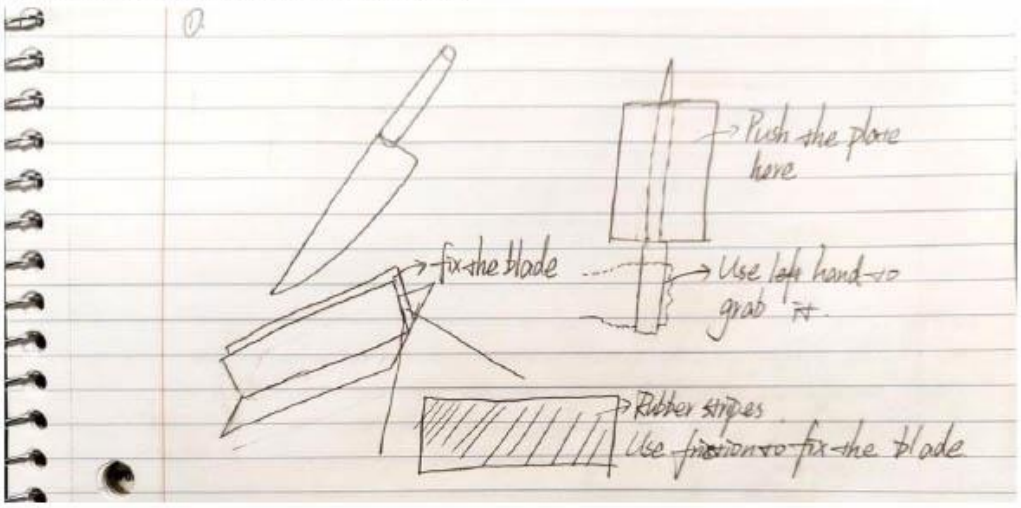
ENGINEER 1P13 – Project Four: ***Power in Community***

Team Number: Thurs-41

Concept 1

Name: Wendong Wang	MacID: wangw198

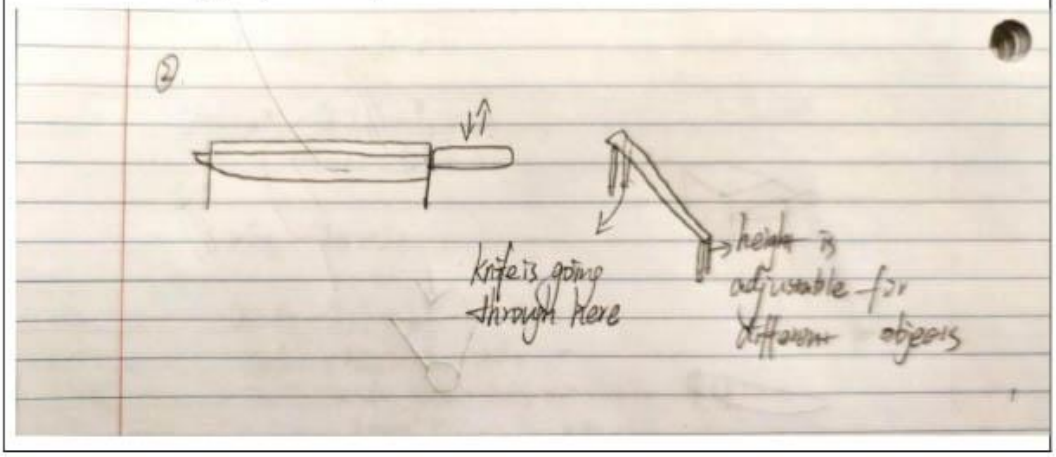
Insert screenshot(s) of your concept below.



Concept 2

Name: Wendong Wang	MacID: wangw198

Insert screenshot(s) of your concept below.



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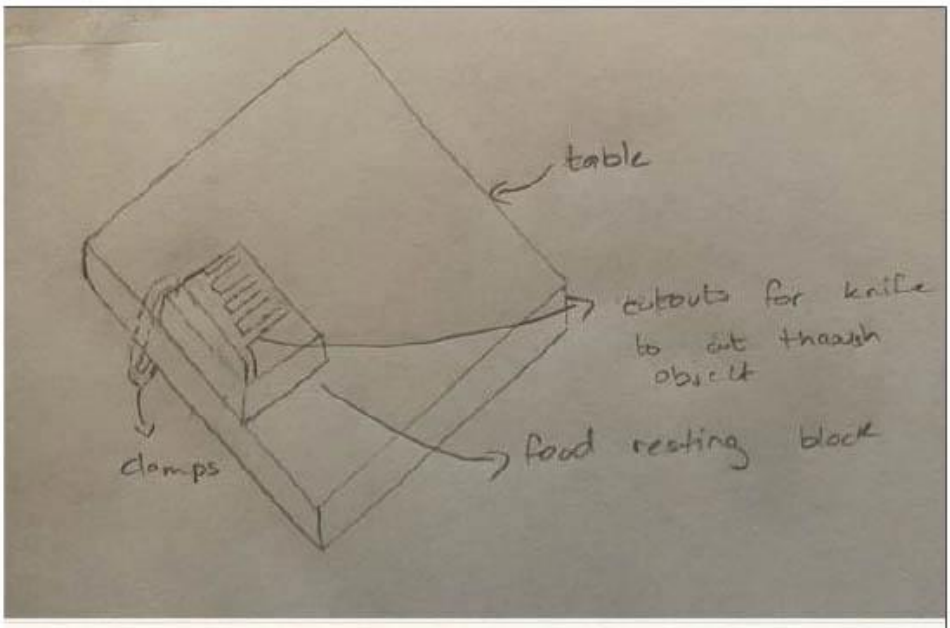
ENGINEER 1P13 – Project Four: ***Power in Community***

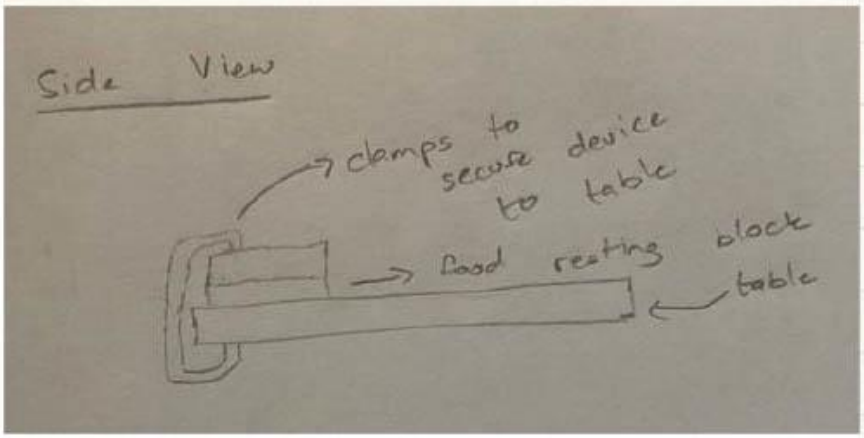
Team Number: Thurs-41

Concept 1

Name: Muhammad Khan	MacID: khanm417

Insert screenshot(s) of your concept below.





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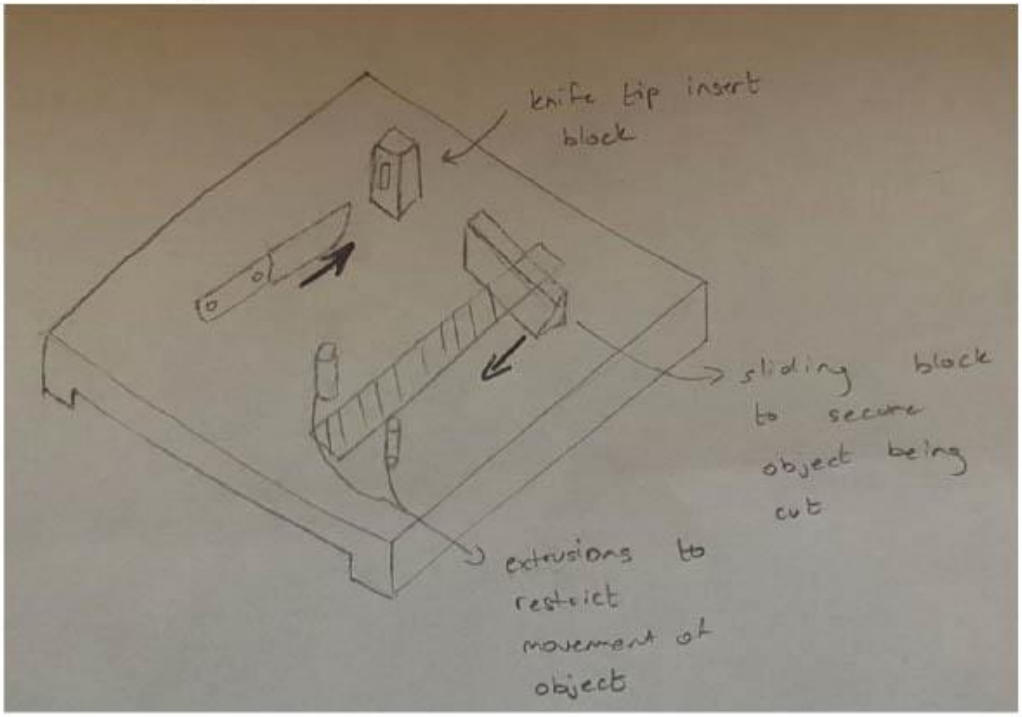
ENGINEER 1P13 – Project Four: ***Power in Community***

Concept 2

Name: Muhammad Khan	MacID: kham417

Insert screenshot(s) of your concept below.



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Milestone 3 Team

ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR: MILESTONE 3 – COVER PAGE

Team Number: Thurs-41

Please list full names and MacID's of all *present* Team Members.

Full Name:	MacID:
Louisa Mueller	muellel
Wendong Wang	wangw198
Muhammad Khan	khanm417
Marisa Patel	patem156

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 3.1 – REFINED CONCEPT: INITIAL PROTOTYPE

Team Number: Thurs-41

1. Copy-and-paste picture(s) of each team member's refined concept (initial prototype) on the following pages (1 team member per page)
   → Be sure to clearly indicate who each refined concept belongs to
2. Include details on how concept was refined (what feedback was incorporated, what features are different than previous concept exploration, etc.)

We are asking that you submit your work on both worksheets. It does seem redundant, but there are valid reasons for this:

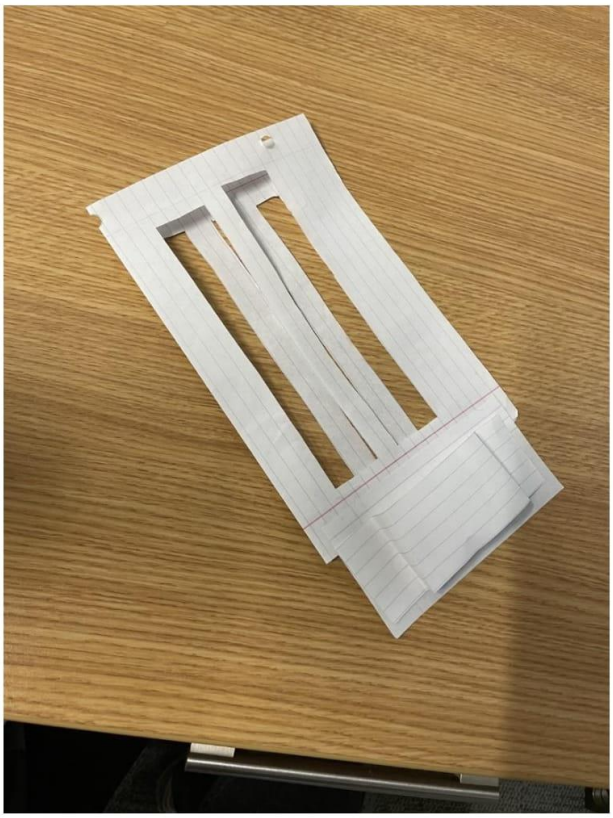
- Each team member needs to submit picture(s) of their refined concept with the **Milestone Three Individual Worksheets** document so that it can be ***graded***
- Compiling your individual work into this **Milestone Three Team Worksheets** document allows you to readily access your team member's work
  - This will be especially helpful when completing the rest of the milestone

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Louisa Mueller	MacID: muellel

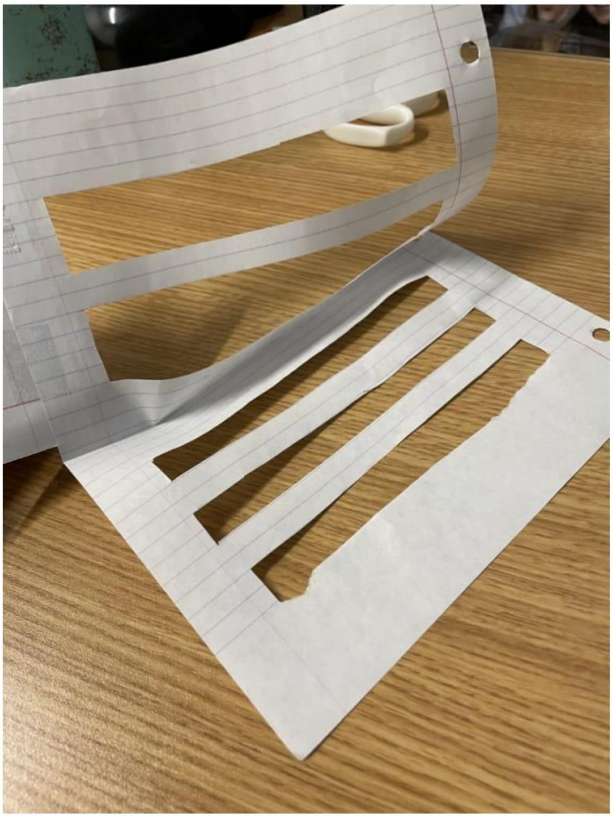
Insert picture(s) of your refined concept (initial prototype) below.



ENGINEER 1P13 – Project Four: *Power in Community*

Name: Louisa Mueller	MacID: muellel

Insert picture(s) of your refined concept (initial prototype) below.



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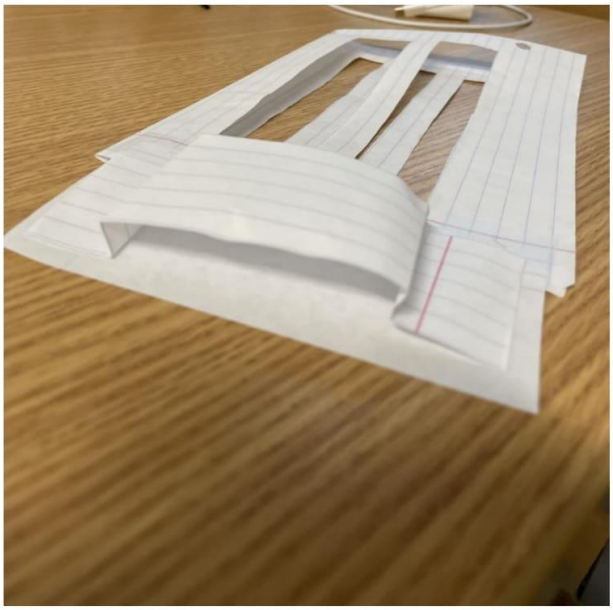
ENGINEER 1P13 – Project Four: *Power in Community*

Name: Louisa Mueller	MacID: muellel

Insert picture(s) of your refined concept (initial prototype) below.



Name: Louisa Mueller	MacID: muellel

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

This device is meant to be an alternative for slicing and cutting food with a knife. The holes cut into the paper are meant to represent blades made of a sharp material that can cut through food. Ideally there are more of these blades, and they are more spaced out so they can cut food into smaller pieces. A folding over action is required to use this device, and adding a handle was a decision I made to make it more comfortable for the user. I went back into the lecture notes I had taken from our first visit with James and noted the handle shape he had incorporated for carrying shopping bags, which he had mentioned was a comfortable shape for him. The handle is rounded and in real life would be made to fit his hand comfortably. Holding the handle will keep his fingers and hand stationary while he will pivot at his wrist when using the slicer.

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Marisa Patel	MacID: patem156

Insert picture(s) of your refined concept (initial prototype) below.

Front View:

Right View:

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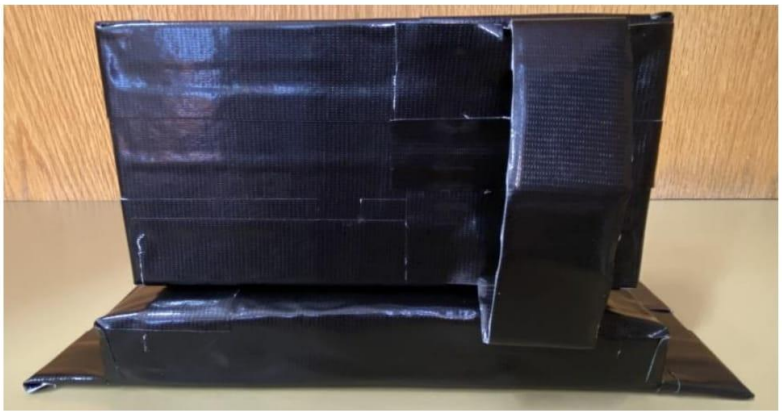
ENGINEER 1P13 – Project Four: *Power in Community*

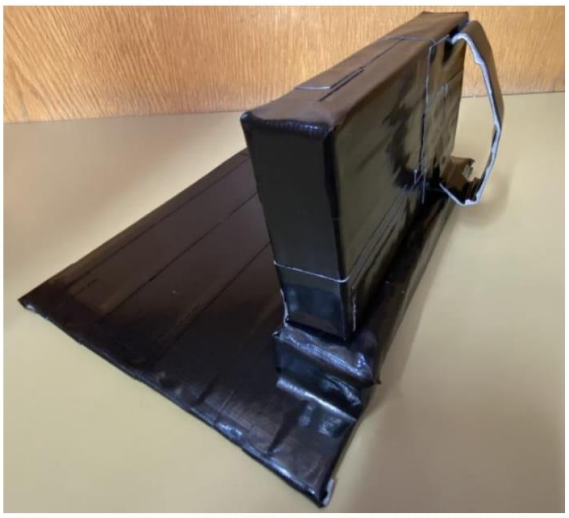
Name: Marisa Patel	MacID: patem156

Insert picture(s) of your refined concept (initial prototype) below.

Back View:



Right Corner View:



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ENGINEER 1P13 – Project Four: *Power in Community*

Name: Marisa Patel	MacID: patem156

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

This concept uses a strap on the back surface of the cutter (or main body), a mount, the main body where the knife blades would be inserted, and its own cutting board attached. The mount is attached to the cutting board, keeping it in place. The user will place the item desired to cut under the blades, while the main body is in its upwards resting position (blades not facing downwards). The user will then insert their hand into the strap as it will hold the hand in place, and push downwards to cut the food product.

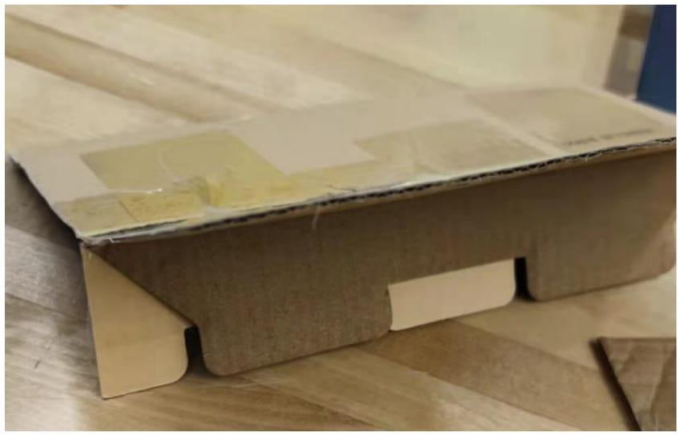
Some feedback that was incorporated into the refined concept was ensuring the mount was one long part rather than two small mounts on the ends of the main body piece. In addition, I used a strap rather than a handle as the user can lay their hand flat using the strap, which can be more comfortable and allow for more control in terms of applying pressure.

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Wendong Wang	MacID: wangw198

Insert picture(s) of your refined concept (initial prototype) below.



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ENGINEER 1P13 – Project Four: *Power in Community*

Name: Wendong Wang	MacID: wangw198

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

Description:

The design is acting like an attachment to the knife so that the client can use left hand to hold the handle and push the plate on the knife to cut stuff. The knife is attached in the groove in the middle. The common gesture to hold a knife would apply pressure to both thumb and index joints because it's splitting the fingers apart (especially Carpometacarpal Joint (CMC Joint) and Basal Carpometacarpal Joint). Meanwhile, since it also requires a fixed position for the wrist and repeat the process many times, it's not friendly to clients with EDS. In this case, my design can help to share the pressure applied to right hand only and transfers it to the entire hand. The left hand is only acting as a support.

Feedbacks:

*P*ros:

1. The design is small and simple
2. It is easy to attach to the knife
3. We can use the knives in his house
4. It is easy to clean

Cons:

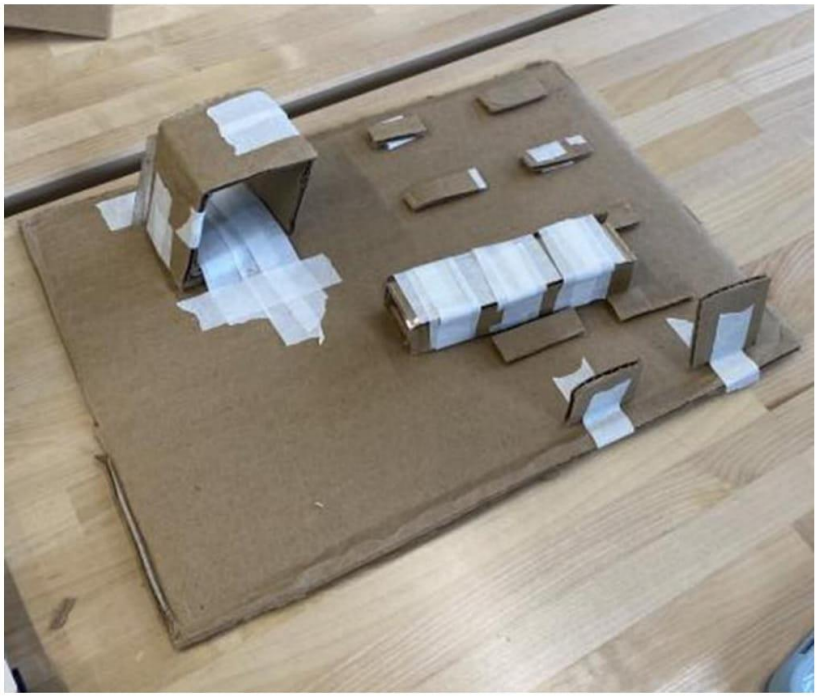
1. The blade is not secured when put into the attachment.
2. Knife may fall when his fingers lose feelings.
3. The way his left hand is holding the handle is not comfortable

ENGINEER 1P13 – Project Four: *Power in Community*

Team Number: Thurs-41

Name: Muhammad Khan	MacID: khanm417

Insert picture(s) of your refined concept (initial prototype) below.



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ENGINEER 1P13 – Project Four: *Power in Community*

Name: Muhammad Umar Khan	MacID: khanm417

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

This prototype works on the basis off restricting exaggerated movement of our client's wrist by securing the tip of the knife in the insert block that can be seen on the top left of the cutting board in the picture above. Whatever our client will be cutting secured by the two extrusions that can be seen on the bottom right of the cutting board. To restrict excess movement of the object our client will be cutting, the presence of the adjustable block and inserts will allow for more security. The knife will be secured by two magnets inside the resting block which will still allow for rotational movement of the knife but will restrict the possibility of the knife slipping out of our client's hands and falling.

Feedback:

- Readjust orientation to allow for ease when using knife with right hand
- What material will the components made out of (food safe & durability)
- Include spring to allow for increase ease
- Consider the cleaning process of the design
- Way to deactivate magnets to easily take out knife

*If you are in a team of 5, please copy and paste the above on a new page.

ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 3.2 – DECISION MATRIX

Team Number: Thurs-41

1. As a team, use a decision matrix to aid you in choosing two concepts to proceed with.
   → Your concept titles should be descriptive (i.e., "Pencil with Hook" instead of "Design A")
      i. If you had your Design Review **before** completing this decision matrix, use the feedback you were given from the review to influence your ratings of your concept(s)

Include your team's Decision Matrix below.

Project 4 Prototypes: Weighted Decision Matrix									
	Weighting	*Prototype 1: Slicer with a Handle*		*Prototype 2: Cutting Board attachment*		*Prototype 3: Hand rest attachment for knife*		*Prototype 4: Fold over slicer*	
		Score	Total	Score	Total	Score	Total	Score	Total
Criterion 1: Hand remains in comfortable resting position	4	2	8	3	12	5	20	3	12
Criterion 2: Restrict excessive wrist movement	3	3	9	2	6	4	12	2	6
Criterion 3: Distribute pressure applied by user	3	4	12	3	9	5	15	2	6
Criterion 4: Able to cut various food products	5	3	15	5	25	5	25	2	10
Total Score			44		52		72		34

2. The numbers you associate with your criteria (objectives and constraints) will probably be an estimation at this point, so **your top two concepts may not always end up being the top two scoring from the decision matrix**. You should provide justification for your team's thought process in choosing the top two concepts. This should include, but is not limited to, explaining:
   - → Your choice of decision matrix tool
   - → Your rationale behind your choice of criteria
   - → Why you prioritized criteria the way that you did (if ranking and/or weighing them)
   - → What metrics you used to decide your scoring of concepts within the criteria
   - → Present your top concept(s) during your Design Review
     i. If you had your Design Review **before** completing this part of the worksheet, your top two concepts may or may not be the ones you presented during your Design Review
     ii. Include in your justification how the Design Review influenced your top concepts

	Insert your team's top two concepts below.
Concept 1:	*Cutting Board attachment with hand rest attachment for knife*
Concept 2:	Slicer with a handle

Include your team's justification below.

We chose to use a weighted decision matrix because it prioritizes certain objectives, making it easier to incorporate them into our design based on their level of importance. Our most heavily weighted criterion weighted at a value of 5 was the fourth criterion, which is the ability to cut various food products, which will make the prototype more adaptable and practical. The other three criteria we chose were our main functions used when completing our functional analysis, and these are all related to making the device as comfortable and easy-to-use for the user as possible. The first criterion weighted at a value of 4 is having the hand remain in a comfortable resting position as this allows for the client to extend the time of use of the device while reducing discomfort. The second criterion weighted at a value of 3 is to restrict excessive wrist movement. This ensures that the prototype reduces the amount of strain in the wrist joints. The third criterion weighted at a value of 3 is to distribute the pressure applied by the client. This ensures that the client's finger/hand joints experience minimal lateral movement. One of our top two concepts chosen was the second one, a cutting board attachment, since it is the easiest to customize to the clients' needs. Additionally, we want to include the hand rest attachment prototype as a component of the cutting board prototype to better displace the pressure applied by the user and keep the hand in a more comfortable position. The second concept chosen was the slicer with a handle which is an easier alternative for using a knife and cuts more food at one time.

ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 3.3 – DESIGN REVIEW

Team Number: Thurs-41

Include your feedback from both your peers and the science students below.

→ Remember to make clear what concept(s) you're receiving feedback for
   i. Use the name of the concept that is used from your decision matrix

Include feedback from peers in this row. *Concept 1: Cutting Board attachment with hand rest attachment for knife (Thurs-43 and Thurs-44 Feedback)* • Find what type of knife the client uses • Flip orientation of cutting block and resting block to make it easier for the client to use since the client is right-handed *Concept 2: Slicer with a handle (Thurs-43 and Thurs-44 Feedback)* • Height of the mount, make it adjustable • Possibly insert the blades • Find a part that will make sure the food being cut does not roll away
Include feedback from science students in this row. *Concept 1: Cutting Board attachment with hand rest attachment for knife* • Spring to help assist the motion (a hinge) to allow the knife to bounce back up • Material selection: laser cut the cutting board, 3D print the rest of the components • Consider making the part replaceable (client can 3D print pieces at home himself if he chooses to) • Consider how would you wash the design (dishwasher, by hand-this is difficult for the client to do) • Is the plastic used in 3D printers food-grade? (3D printers in design studio use 0.2mm PLA) • Being able to cut lengthwise and widthwise • Putting the knife block on a swivel

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- Way to easily detach the knife
- Is the material durable under a knife? (cutting board) If not, how would we secure the cutting board? Consider using an old cutting board (something that the client already has, and print components that can be attached to his cutting board)

Concept 2: Slicer with a handle

- Hard to cut shorter products, make the block adjustable or have alternate blades
- Find a way to retract the blade into the mechanism to protect himself from accidentally cutting himself (so he is able to store the device)
- Material selection: Possibly laser cut the cutting board
- Velcro that is lined with fleece or soft material is a good idea for the hand strap
- Consider how would you wash the design (dishwasher, by hand-this is difficult for the client to do): make the strap come off, if the blade and cutting board can detach we can put that into the dishwasher)
- Find a way to make the food product go somewhere after it is cut (so it doesn't pile in one spot)
- Find a way to be able to see where the user is cutting
- Be able to switch between a horizontal or vertical blade (to cut lengthwise or widthwise)
- Is the material durable under a knife? (cutting board) If not, how would we secure the cutting board? Consider using an old cutting board (something that the client already has, and make the components so that it can be attached to his cutting board)

Milestone 4 Team

ENGINEER 1P13 – Project Four: *Power in Community*

PROJECT FOUR: MILESTONE 4 – COVER PAGE

Team Number: Thurs-41

Please list full names and MacID's of all *present* Team Members

Full Name:	MacID:
Louisa Mueller	muellel
Wendong Wang	wangw198
Marisa Patel	patem156
Muhammad Khan	khanm417

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ENGINEER 1P13 – Project Four: *Power in Community*

MILESTONE 4.1 – REFINED PROTOTYPE & PROTOTYPING TEST PLAN

Team Number: Thurs-41

1. Take picture(s) of your refined prototype.
   - → Include picture(s) of your previous prototypes(s) that you either decided to further refine or take elements from to create your refined prototype. Only include relevant previous prototypes
   - → Insert your photo(s) as a Picture (Insert > Picture > This Device)
   - → **Do not include more than *two* pictures per page**

Insert picture(s) of your previous prototype(s) below. These should be the prototypes that are relevant to your current prototype, and can be used as proof of the iteration process

Front View:

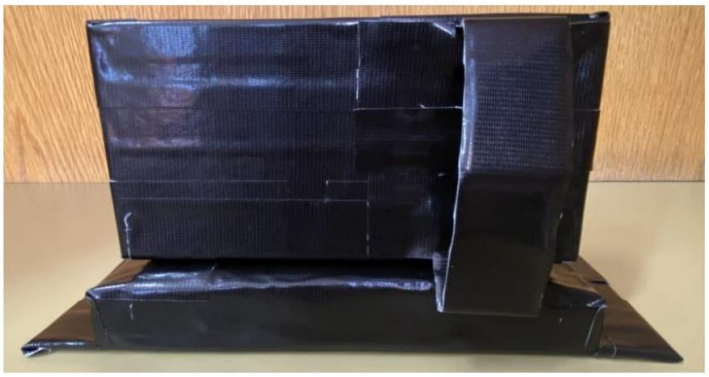
Right View:

*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

ENGINEER 1P13 – Project Four: *Power in Community*

Insert picture(s) of your previous prototype(s) below. These should be the prototypes that are relevant to your current prototype, and can be used as proof of the iteration process

Back View:



Right Corner View:

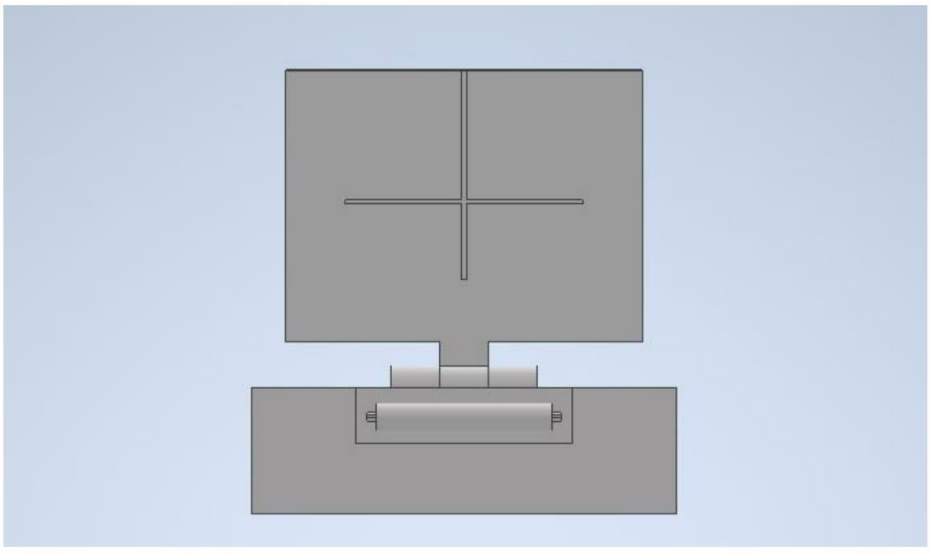
*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

ENGINEER 1P13 – Project Four: *Power in Community*

Insert picture(s) of your refined prototype below.

Front View Physical Prototype:

Front View CAD Model:



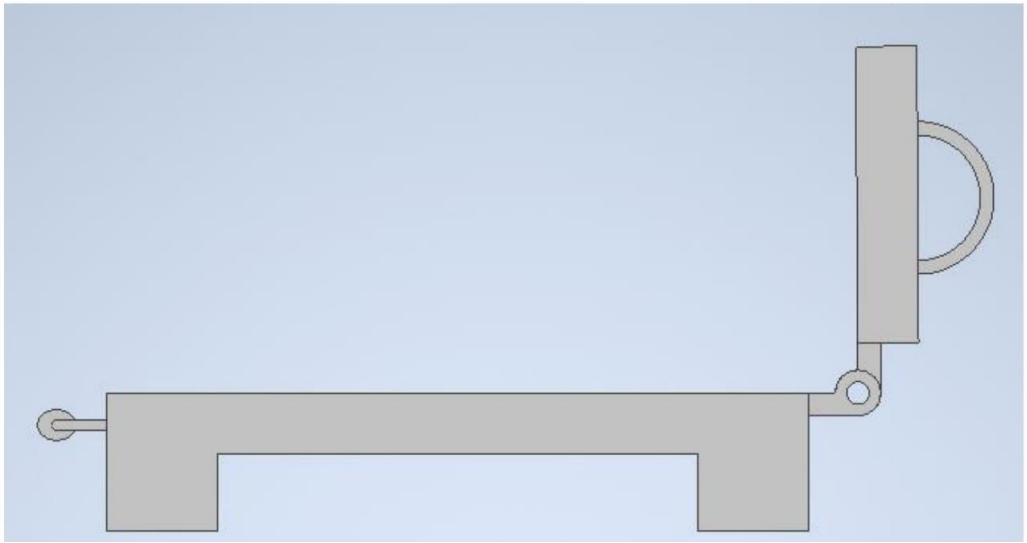
*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

ENGINEER 1P13 – Project Four: *Power in Community*

Insert picture(s) of your refined prototype below.

Right View Physical Prototype:

Right View CAD Model:

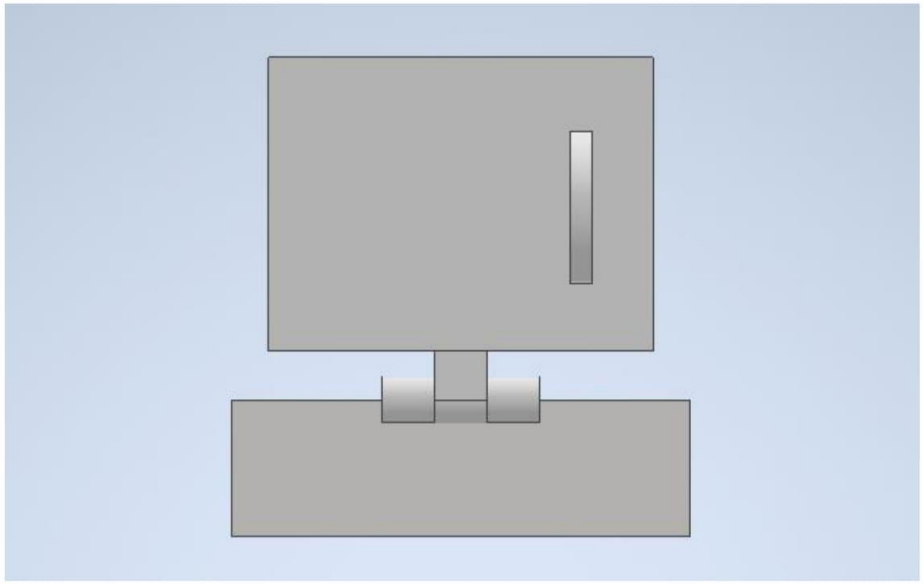


*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

Insert picture(s) of your refined prototype below.

Back View Physical Prototype:

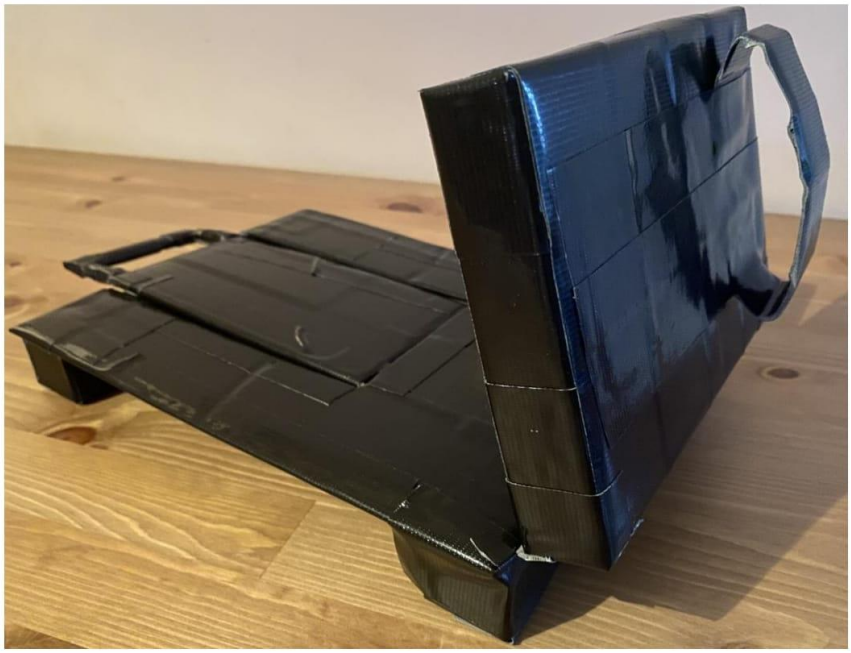
Back View CAD Model:



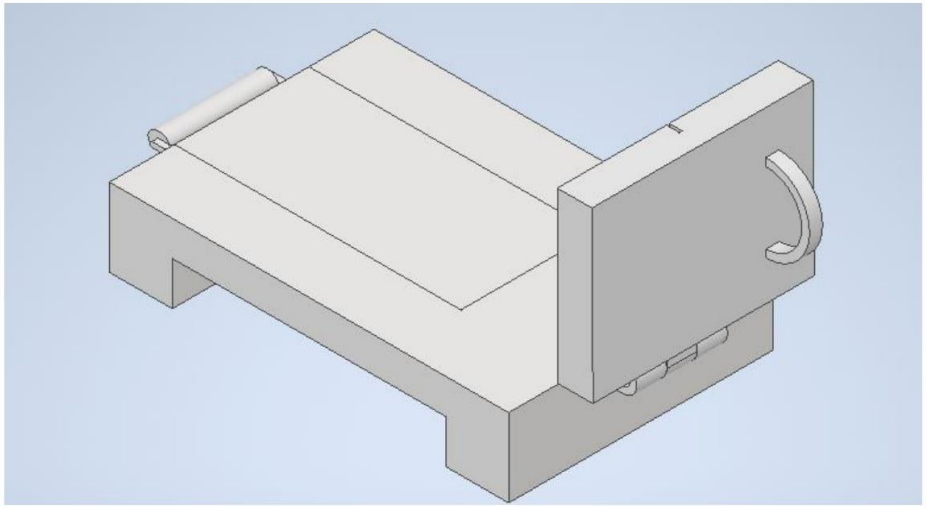
*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

Insert picture(s) of your refined prototype below.

Right Corner View Physical Prototype:



Right Corner View CAD Model:



*Limit screenshots to no more than 2 per page. For additional screenshots, please copy and paste the above on a new page.

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Team Number: Thurs-41

2. Include details on how design concept was refined (what feedback was incorporated, what features are different than previous refined concept (initial prototype), etc.).

Include details on your thought process and how the concept was refined below, with notes on relevant feedback that was incorporated ***(max. 200 words).***

Our refined design uses a slicer attachment, cutting board, hinges, cut-out that slides out in the cutting board with a handle, a hand strap, and blades. We changed our initial prototype by implementing the feedback provided. We tried to alter the height of the device by adding legs to the cutting board to allow the client to cut better. We also used hinges instead to attach the slicer to the cutting board. We created a cut-out in the cutting board to allow for the client to move the food product he has cut without having to put his hands under the area where the blades will be, ensuring his safety. This was another thing we took into consideration given our feedback to make it safer for the client. We were also advised to ensure the client can cut both lengthwise and widthwise to allow for more versatility, which is why we created a length and widthwise blade insert. Our new design now works by the client putting his hand into the strap, placing the blades inside the selected slots, placing the food product, rotating and pressing down, and then sliding the cut-out outwards to drop the food down.

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Team Number: Thurs-41

3. Create a detailed prototype testing plan. (**max. 500 words** TOTAL for present and future plan)
   - → Consider what is feasible with the resources you have
   - → "Testing" can include analytic solutions such as hand calculations and motion simulations in Inventor
   - → Explore what you might do if you had more time, money, tools, etc.
   - → Use IEEE referencing if any research is done

*Insert your **Present Testing Plan** (how you would test your prototype with the resources that you have available).*

User Safety: Check for sharp features (corners, blades). Blade attachments are inserted into slot when device is in use but can be removed when in storage.

Lightweight: Weigh slicer attachment on a scale to ensure it is not unreasonably heavy for the client to use. Weight should be distributed evenly across the attachment based on hand placement (hand should be flat).

Easily Cleaned: Parts that touch food directly can be detached and sanitized separately from the entire prototype.

Adjustable: Two different blade attachments, one lengthwise and one widthwise, so objects can be cut in chosen orientation.

Ability to cut/slice: Material used for blade inserts is durable and sharp enough to facilitate cutting of food objects.

*Insert your **Future Testing Plan** (how you would test your prototype with the resources that you do not currently have available but may have in the future).*

User Safety: With more time, find a better placement of the wrist strap away from the blades to avoid safety hazards. Blade attachments can be securely placed into slot, so they do not fall out when device is in use. Additionally, with access to more materials, we could test multiple wrist straps to find the most comfortable one.

Lightweight: Try and have our client and other individuals to test out our prototype to get feedback on the weight distribution along with overall weight of our design.

Easily Cleaned: Detachable components are the ones coming in contact the most with the food, and material used is food grade and able to be cleaned properly.

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Adjustable: Produce more blade attachments of different sizes and spacing rather than just orientations.

Ability to cut/slice: Try to cut a simple object such as a banana using the prototype using both blade attachments.

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Team Number: Thurs-41

4. Fill out the table below, detailing each team member's contribution to this stage

Team Member's Full Name:	Contribution:
Louisa Mueller	In this stage, I created the cutting board with the legs for the AutoDesk Inventor CAD model.
Wendong Wang	In this stage, I created the hinge attachments and the handle for the cut-out in the cutting board for the AutoDesk Inventor CAD model
Muhammad Khan	In this stage, I created the slicer attachment for the AutoDesk Inventor CAD model.
Marisa Patel	In this stage, I created the physical prototype. I also assembled all the .ipt parts into an assembly file (.iam).

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MILESTONE 4.2 – DESIGN REVIEW

Team Number: Thurs-41

Include feedback from peers in this row.

Refined Prototype Feedback: Thurs-51

- Can the blades be replaced? If they are dull, he will need to apply more pressure
- How versatile are the blades (width and lengthwise cutting)
- Amount of pressure applied (cannot use very big/harder to cut food products)

Include feedback from science students in this row.

Refined Prototype Feedback:

- Button or some mechanism to unlatch blades
- Efficient
- How will it be secured to the table (pads made from rubber to keep board stagnant while it is on the table)
- Some sort of device to push food into the cut-out in the board
- Some premade containers that can just slip out or something to catch the product
- Play around with the elevation and find the perfect height where it isn't too tall
- Drawer type mechanism
- Something to catch the food
- Plastic sleeves or covers before the client removes blades
- An easy way to take out the blades
- Have a couple of fail-safes to prevent an accident
- Protective covering on sides of slicer attachment
- Elbow resting on the block

If applicable, include feedback from your faculty mentor, staff, or assigned TA/IAI

Refined Prototype Feedback:

- We can make the cutting board taller so that the client can reach his hand under the board
- The blades can go back inside when the upper part is lifted and goes down while cutting
- The knife can stay inside the board (slots in the board for the blades) - keeping the upper part down on the board
- We can store the blades in the upper part instead of removing them
- Create a plate with blades on it so that we can simply take out the plate instead of the blades