Knee Crutch

Date: 10/7/25
Client: Daniel Kutschera
Advisor: Randy Bartels

Team:
Violet Urdahl - Team Leader (vurdahl@wisc.edu)
Tess Fitzgerald - Communicator (tkfitzgerald@wisc.edu)
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Problem Statement:

Knee crutches are an assistive device used to help non-weight-bearing patients recovering from a lower limb injury move efficiently and comfortably. Current devices available target assistance with walking, but are not suitable for ascending or descending stairs. To ensure patients can get home safely, the improved knee crutch will provide ample stability and assistance for stair climbing without the additional use of crutches. The goal is to create an improved version of an existing prototype that will provide users with sufficient mobility and stability when climbing stairs.

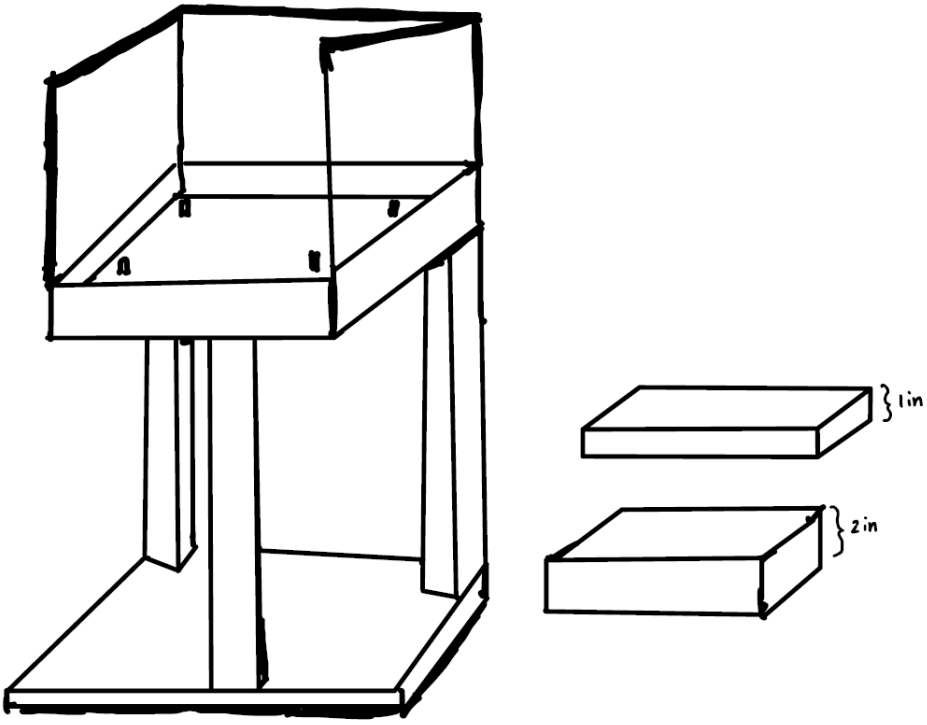
Brief Status Update:

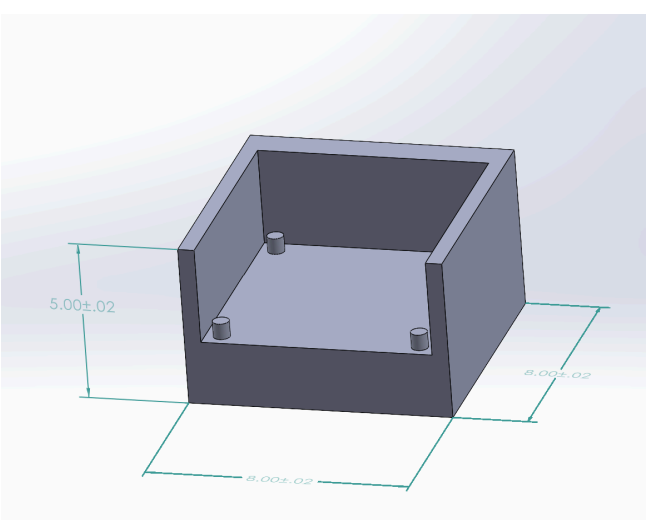
The team prioritized the preliminary report this week. We evaluated all components of the design and created a comprehensive summary of our current and future work. The team also decided on a final design, which is the Frankenstein design with some small modifications to increase ease of fabrication. This change in design correlates to the base design, which instead of being composed of a plate will be made of an extruded aluminum ‘frame’ for ease of fabrication. We also took the time to evaluate one another as teammates to optimize team cohesion.

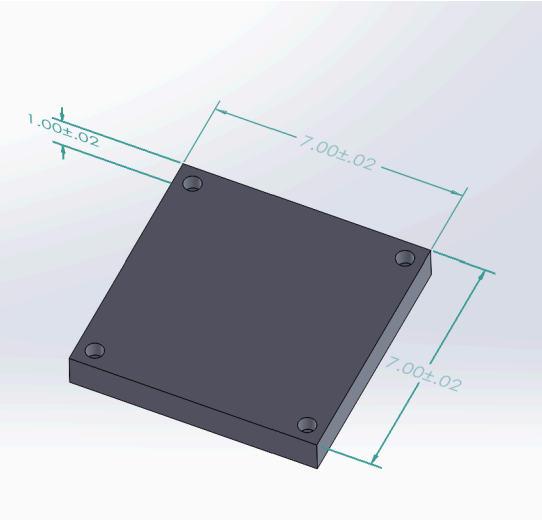
Project Difficulties/Advice Requests:

- None to report

Current Design:







Materials and Expenses:

- See table below:

Item	Description	Manufac-turer	Date	#	Cost Each	Total	Link
HDP	3D printing material for knee support	Makerspace	Have not purchased	N/A	N/A	$0.00	
Extruded Aluminum	Material for legs and knee support frame		Have not purchased	N/A	N/A	$0.00	
Memory foam cushion	Material for knee to rest directly on		Have not purchased	N/A	N/A	$0.00	
Rubber base	Material for non-slip bottom base		Have not purchased	N/A	N/A	$0.00	
					TOTAL:	**$0.00**	

Team Goals for Upcoming Week:

- Finalize fabrication plan for final design
- Begin ordering materials
- Reflect on peer feedback
- Continue research

Individual Goals for Upcoming Week:

- Tess Fitzgerald
    - Order materials for fabrication
    - Finish solidworks file and 3D at makerspace
    - Review peer feedback on Feedback Fruits and write reflection
- Aubrianna Younker
    - Finalize and order materials
    - Update deliverables in the team's lab notebook
    - Review peer feedback and assess how I can improve as a member of this team
- Lauren Anderson
    - Order materials with our team
    - Connect with Tess about fabricating the top of the base, working with autoCAD and 3D-printing
    - Look at my peer review and reflect on actionable steps to improving my contributions to the team
- Violet Urdahl
    - Review team feedback and make adjustments to my teammate behaviors to optimize team work
    - Create a fabrication plan for the base
    - Order materials for the base
- Kayla Christy
    - Review feedback from feedback fruits and make adjustments
    - Finalize and order materials with the group
    - Review our teams progress and make a plan of next steps
    - Attend the next BSAC meeting
- Evan Koelemay
    - Work on a plan for the fabrication of the base
    - Read and reflect on Feedback Fruits
    - Learn the process of ordering materials

Timeline

Task	September				October				November					December	
	5	12	19	26	3	10	17	24	31	7	14	21	28	5	10

Deliverables															
Progress Reports		**X**	X	X	X	X									
PDS Draft			X												
Design Matrix				X											
Preliminary Presentations					X										
Preliminary Lab Notebook															
Preliminary Report						X									
Preliminary Evaluations						X									
Show and Tell															
Final Poster Presentation															
Final Lab Notebook															
Final Report															
Final Evaluations															
Meetings															
Team	**X**		X	X	X	X									
Client	X			X		X									
Advisor			X		X										
Website															
Update	**X**	X	X	X	X	X									

Previous week's goals and accomplishments:

- Tess Fitzgerald
    - Set up meeting with client
    - Made prototype of knee support and height adjustment blocks on SolidWorks
    - Contributed to final design
    - Researched foot to knee length of adult humans
- Aubrianna Younker
    - Developed testing protocols and refined preliminary report
    - Researched standards and fabrication methods
    - Spoke with the client about expectations for ordering materials
    - Evaluated teammates, giving constructive feedback
- Lauren Anderson
    - Worked with team to lay out a plan for fabrication
    - Wrote and edited the preliminary report
    - Evaluated the work of my teammates and gave feedback
    - Presented preliminary presentation
- Violet Urdahl

    - Designed on materials for components of each design
    - Created preliminary fabrication plan
    - Condensed fabrication plan and material plans for preliminary report
    - Researched previous group's work on this project
- Evan Koelemay
    - Worked on preliminary report
    - Participated in team meeting with client to discuss fabrication plans
    - Completed teammate evaluation
- Kayla Christy
    - Reviewed meeting notes from meetings I was unable to attend
    - Filled out my portion of the preliminary report
    - Presented our preliminary presentation
    - Evaluated my teammates on feedback fruits.

Activities

Name	Date	Activity	Time (h)	Week Total (h)	Sem. Total (h)
Violet Urdahl	10/8/25	Finished preliminary report, feedback fruits, and conducted research	3	3	12.5
Aubrianna Younker	10/9/2025	Testing protocol development, research, and preliminary report work	3.5h	3.5h	13.5h
Tess Fitzgerald	10/9/2025	SolidWorks file, preliminary report, peer evaluation, individual research	3.5	3.5	13
Lauren Anderson	10/6/2025	Worked on fabrication plans. Wrote pieces of the preliminary report and wrote teammate feedback	3h	3h	12.5h
Evan Koelemay	10/9/2025	Client/team meeting, preliminary report, peer evaluation	3h	3h	11.5
Kayla Christy	10/6/25	Fabrication plans, preliminary presentation, peer evaluation, preliminary report.	3.5h	3.5h	13.5
Whole Team	10/6/25	Fabrication plans, material choices, and preliminary report	1h	2h	9.5h
Whole Team	10/6/25	Client Meeting	1h		

Design Matrix

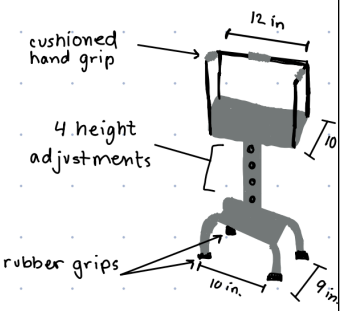
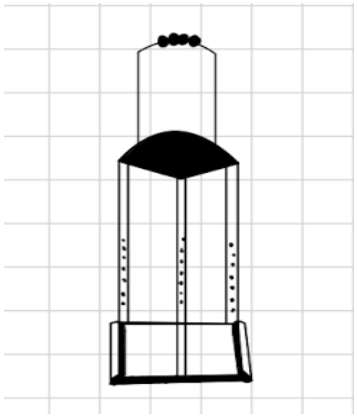
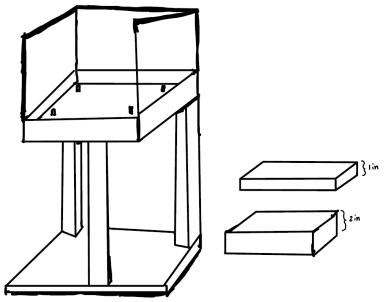
Design Idea Descriptions

Wrap Around Handle
This design features a wide 9x10-inch base, supported by four small, curved legs with rubber caps on the bottom for added stability. Attached to this base is a long, adjustable square rod that supports a flat plate parallel with the ground. This flat plate is where the patient rests their knee and where a knee cushion can be placed for added comfort. Around that knee support is an extended handle. The patient can utilize this for support while pushing themselves up the step and also to help lift the device from one step to the next. It wraps around 3 of the 4 sides of the knee support plate, allowing the patient to find a grip location that works best for them. Lastly, all components of this design are made of aluminum.

Adjustable Three Leg
This design features a three-legged base that stabilizes the cushion on the top. The base is a square shape that is hollow in the middle to avoid excess weight in the crutch. There is a silicon cap that wraps around the base to stabilize the knee crutch on slick surfaces. Each of the three legs are adjustable using a pin and hole mechanism. The top has a curved and cushioned pad that uses the curvature as lateral support for the patient's knee. The handle is placed on the front of the device, and is cushioned with a handle. The main materials for this design would include metal (aluminum or steel) and foam.

The Frankenstein
This design is an amalgamation of components from the team’s individual designs. The handle component wraps around three sides of the knee support, allowing users to place their hand wherever is most comfortable when ascending and moving the device up stairs. There are three legs for support, allowing the design to be both stable and lightweight. Additionally, these supports are not adjustable, eradicating the possibility of instability that accompanies adjustability. The leg support is curved, creating lateral support of the knee when placed in the crutch. This leg support is also cushioned to allow the user to be comfortable when using the knee crutch. To accommodate for the lack of adjustability in the legs, the base of this knee support has stackable blocks that can be added beneath the knee cushion, allowing the height to be adjusted to best fit the user. Finally, the base, or ‘foot’ is wide and flat, allowing the

structure to have more security in use. It also has a rubber tread component to increase friction between the base and the stair, minimizing the risk of slipping. This design's frame will be made of aluminum, the cushion out of foam, and the tread rubber.

Knee Crutch Design Matrix	**Wrap Around Handle** 		**Adjustable Three Leg** 		**The Frankenstein** 	
	Score out of 5	**Weighted Score**	**Score out of 5**	**Weighted Score**	**Score out of 5**	**Weighted Score**
Ease of Use (25)	**4**	**20**	**4**	**20**	**5**	**25**
Safety/Stability (25)	**3**	**15**	**3**	**15**	**5**	**25**
Weight (15)	**5**	**15**	**4**	**12**	**4**	**12**
Comfort (10)	**5**	**10**	**4**	**8**	**5**	**10**
Ease of Fabrication (15)	**2**	**6**	**3**	**9**	**4**	**12**
Cost (10)	**3**	**6**	**3**	**6**	**4**	**8**
Total (100)	**72**		**70**		**92**	

Criteria for Model Design Matrix:

Ease of Use:

The “ease of use” criteria gauges the degree to which each design satisfies the needs of the patients, specifically their ability to utilize the device. This includes analyzing the different components of each design and its contribution to completing the intended task: climbing stairs with an injured lower extremity. It will consider how easily the device can be lifted from one step to another, looking at handle design and placement. It will also consider the functionality of the device, aspects like heights of any handles and knee supports. This criteria was weighted higher than the rest, 25/100, because the patients are the main demographic for these devices so having strong functionality and being easy to use needs to be a key component in all design considerations.

Safety/Stability:
The safety of users is one of the most important considerations to be made when evaluating possible designs. Stability of the device being a key factor in safety; the base support and foot are crucial components in determining if users will be able to maintain their balance. Additionally, the handle design impacts the usability and safety of the device. These three factors were taken into account when assigning safety rankings for each respective design. Due to the high importance of the device’s stability, this criteria was ranked 25/100.

Weight:
The weight component of the design involves both the total weight of the product itself, as well as the distribution of weight that factors into stability. It is important that the design is lightweight and easy to maneuver to accommodate the needs of the client’s patients, most of whom are elderly. While having a lightweight design is ideal, this factor isn’t as crucial as safety or ease of use, leading to the rank of 15/100.

Comfort:
The criteria for comfort assess the support and give of the device. This includes assessing if the patient's knee fits comfortably into the curved cushion on the knee support. It will also consider how large the platform is and how much cushion the support provides to the patient's knee. Additionally, it will take into account the curvature of the cushion and the placement of the handle on the device. Finally, the cushion on the handle will be analyzed to make sure the downward force on the handle will be cushioned. Comfort was weighted 10/100 because although it is a favorable feature to include, it is not as functionally relevant as ease of use, or stability.

Ease of Fabrication:
The ease of fabrication is an important factor when deciding on the final design. The design should be able to be fabricated using the resources and materials available to the team. The client has been generous with the budget for this project, so fabrication complexity can range and does among the three possible designs. However, all of the possible designs are capable of being fabricated, and therefore this criteria was given a lower weight of 15/100, compared to Ease of Use and Safety, in the design matrix.

Cost:

Cost is an important factor when choosing a final design, however, it is less important than some of the other criteria given the flexibility of the teams budget. The current budget for the device is around $500, based on client feedback. Cost can be minimized by careful selection of materials, and prioritizing ease of fabrication. As a result, the cost criteria was weighted 10/100.

Discussion

The final design selected is the Frankenstein design. This design was chosen because of its exceptional performance across the criteria outlined in the design matrix, giving it the highest overall score. The Frankenstein design scored highest out of all three designs for the criterias with the greatest weight – Ease of Use and Stability. This is due to the height adjustability component, which uses a stackable block that is secured to the leg rest using a peg mechanism. Using a stackable block on the leg rest instead of a pinhole mechanism on the legs allows for greater stability as the legs will remain solid. This also makes the device more versatile to different heights and anthropometric ratios, improving its ease of use. The Frankenstein did rank lower in the Weight category, and this is because of its three legs. Though it will still meet the client's requirements, the three legs may make the device heavier than if it had one. This design also scored the highest in Comfort because of its wrap-around handle; the user is able to support themself and lift the device on whatever side is most comfortable for them with this design. Additionally, the Frankenstein scored the highest in ease of fabrication because unlike the other designs, it does not have adjustable legs, leaving less room for error. Finally, the Frankenstein scored highest in Cost because the team will be able to use more raw materials when fabricating. Adjustability components are more expensive, so removing this variable lowers its overall cost. Due to the fact that the Frankenstein scored the highest overall by 20 points, the team has opted to proceed with this design.