Knee Crutch

Date: 9/25/25
Client: Daniel Kutschera
Advisor: Randy Bartels

Team:
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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.

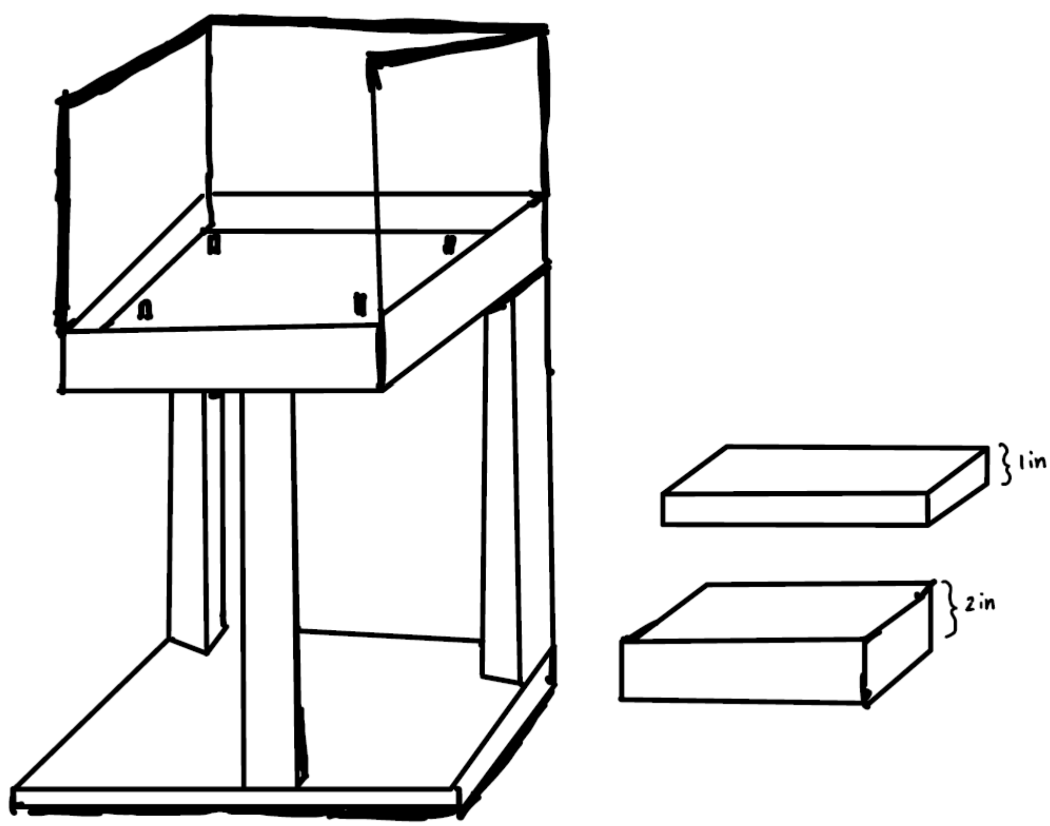
Brief Status Update:

This week, the team developed several design ideas and established design criteria to create a design matrix. This matrix revealed our winning preliminary design idea: The Frankenstein. This design won in the following categories: comfort, ease of use, cost, and safety/stability. It implements a large aluminum base, three legs, and a wrap-around handle. Additionally, the team met with our client a second time to give design updates and receive materials and old prototypes.

Project Difficulties/Advice Requests:

- None to report

Current Design:



Materials and Expenses:

- None to report, see table below:

Item	Description	Manufac-turer	Mft Pt#	Vendor	Vendor Cat#	Date	#	Cost Each	Total	Link
Category 1										
									$0.00	
									$0.00	
								TOTAL:	**$0.00**	

Team Goals for Upcoming Week:

- Solidify expectations, responsibilities, and roles for the preliminary presentation
- Research potential materials for our prototype: considering cost, strength, weight, safety, and other factors
- Have an in-person meeting with our advisor, Professor Bartels, to do introductions, updates, and ask questions

Individual Goals for Upcoming Week:

- Tess Fitzgerald
    - Finalize physical specifications for design (dimensions, weight capacity, materials)
    - Begin fabrication protocol
    - Create preliminary presentation
- Aubrianna Younker
    - Work on my presentation skills before our preliminary presentation
    - Start writing a preliminary fabrication protocol for our winning design
- Lauren Anderson
    - Work on the preliminary presentation and practice my presentation skills
    - Continue research to finalize the design aspects
    - Research the biological factors
- Violet Urdahl
    - Finalize preliminary presentation
    - Finalize dimensions of design
    - Work on fabrication protocol
- Kayla Christy
    - Do more research on standards and specifications
    - Include more detail in my preliminary design like strength, weight, safety, cost, and materials
    - Attend the next BSAC meeting
- Evan Koelemay
    - Research values on stress failure of the intended materials to get a better idea on the needed dimensions
    - Help finalize design

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											
PDS Draft			X												

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

Previous week's goals and accomplishments:

- Tess Fitzgerald
  - Made drawing for final design
  - Met with team to discuss designs and complete design matrix
  - Contacted client and advisor to organize meetings
- Aubrianna Younker
  - Made a preliminary design drawing implementing a unique wrap-around handle competent
  - Researched anthropometric tables and calculated a few basic average leg and arm length values
  - Took meeting notes and filled out group portions of the progress report
- Lauren Anderson
  - Attended the executive BSAC meeting to stay up to date on the curriculum conversation
  - Finished my preliminary designs and shared them with my team to create the design matrix
  - Finished my portion of the design matrix
- Violet Urdahl
  - Made a preliminary design based on client requirements
  - Met with team and created design matrix/evaluated individual designs

  - Finished Design Matrix
  - Researched dimensions and anthropometric measurements for our design
- Evan Koelemay
  - Created a preliminary design to share with the team
  - Worked on the Design Matrix
  - Research on ergonomic grip/handle designs
- Kayla Christy
  - Created two preliminary designs and uploaded them to LabArchives
  - Finalized my portion of the pds
  - Worked on my portion on the Design Matrix

Activities

Name	Date	Activity	Time (h)	Week Total (h)	Sem. Total (h)
Violet Urdahl	9/25/2025	Created preliminary design, researched anthropometric tables and standard stair dimensions. Completed design matrix	3	3	7
Aubrianna Younker	9/25/2025	Design drawing, research/calculations, meeting notes, and progress report	3	3	7
Lauren Anderson	9/25/2025	Design drawings, design matrix edits, progress report	3	3	6.5
Tess Fitzgerald	9/25/2025	Design drawing, research, design matrix criteria, justifications	2.5	2.5	6.5
Evan Koelemay	9/25/2025	Preliminary design, research, design matrix	2	2	5.5
Kayla Christy	9/25/2025	Worked on preliminary designs, research on standards and specifications, progress report, and design matrix.	3	3	7
Whole Team	9/19/2025	Met to discuss deliverables	1	2	5
Whole Team	9/22/25	Created design matrix	1		

Design Matrix

Design Idea Descriptions

Wrap Around Handle

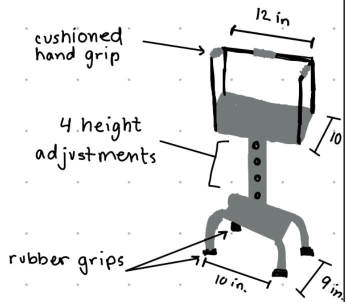
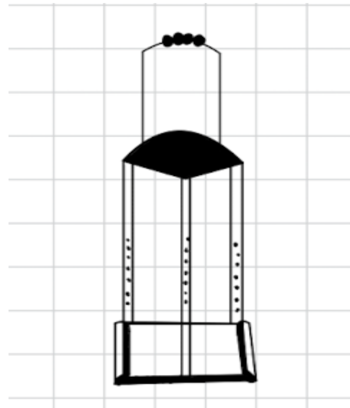
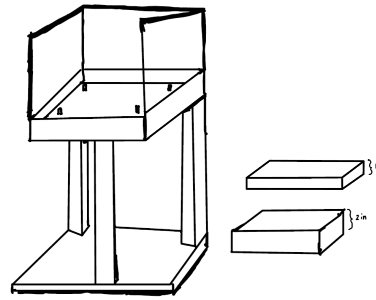
This design features a wide 9x10-inch base, supported by four small, curved legs with rubber caps on the bottom for added stability. Attached to this base is a long, adjustable square rod that supports a flat plate parallel with the ground. This flat plate is where the patient rests their knee and where 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.