

**GNG2101 - Lab Section B03**

**Deliverable C.1:**  
*Conceptual Design*

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# Abstract

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The following document outlines the different steps of the Ideation Process part of the *Iterative Engineering Design Process Model*, as it was put into action by GNG2101 Project Team B31.

First, the team performs a functional decomposition based on the problem statement and functional requirements determined during the course of the previous deliverable.

Second, each team member presents three different designs based on the aforementioned requirements, putting special emphasis on the functions and sub-functions determined during the decomposition.

Third, these designs were evaluated, using a numeric evaluation method, and a final solution was synthesized from the many good ideas spread throughout the many proposed concepts. This final solution, based on member Ashley Larocque's first design (which had the highest score), manages to maximize its adherence to the many requirements.

Thus, this report concludes in the successful establishment of the design to be used as the strict model for the first prototype, to be designed in the following weeks.

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# 1. Introduction

Engineering design is distinguished from many other forms of work, in that it requires a decent amount of creativity to be exercised. In order to do this, engineers can opt for a number of approaches. One well-known technique is the “brainstorm”, wherein a group of people, usually a project team, attempt to come to an optimal solution by each throwing out, and then combining, a large amount of ideas, all conceptualized according to a limited set of constraints.

Such is essentially the exercise performed and detailed in the following document. Here, the members of team B31 utilize the functional requirements, determined in previous weeks, to each come up with multiple possible solutions to their client’s problem. After the designs are presented, they will be evaluated according to their ability to meet each design requirement, and the results will be the subject of discussion. Finally, the document presents the fully realized design that the team will have agreed upon. This design is expected to combine aspects from multiple concepts, such that it will meet the functional requirements better than any single one.

## 2. Engineering Design Process

Common to most engineering design process models is the “ideation” stage. The team’s chosen model, the *Iterative Engineering Design Process* is no exception.

This ideation stage is a crucial one, wherein the project team comes up with their solution concepts, and from them synthesizes a definitive design, which will guide the construction of the first prototype.

## 3. Functional Decomposition

We recall that the client desires the following:

*“[A set of] rigid panels that will close the side gaps [of a wheelchair’s armrest], and offer a comfortable, affordable and easy to install experience.”*

As such, we are able to make the following observation about the final product itself. For example, we can say that its **core functionality** is the closure of the gaps. From there, we can break down a few sub-functions as well:

- How the panels attach to the chair
- How the user is able to stabilize/tighten said attachment.
- How the panels detach from the chair (a reverse of the first sub-function).

As such, we have the following functional decomposition, summarized in two figures:

Figure 1:



Figure 1. High-level functional decomposition

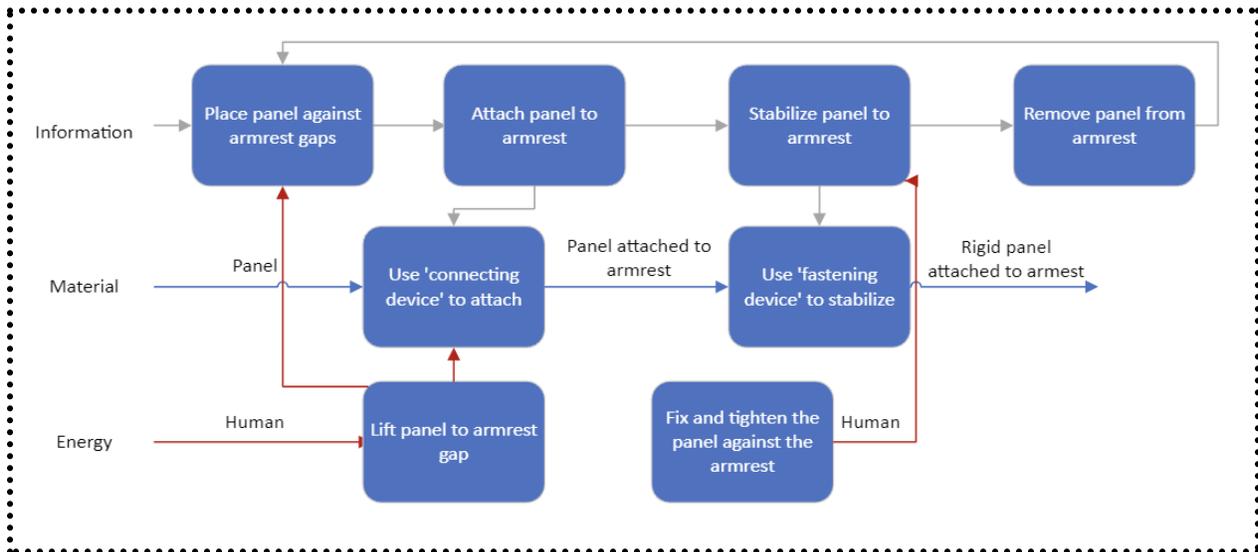


Figure 2. Low-level functional decomposition

## 4. Product Concepts

### 4.1 Individual Design Concepts

*In this section, each group member will propose three ideas for the conceptual design of the arm gap panels. The designs will be compared using a weighted decision matrix, to determine which concepts should be used and combined with others to produce the final group design.*



Figure 3. Flipback armrest

#### 4.1.1 Ashley

##### Design 1:

The first proposed panel would fit under the existing panel on the flip back armrest. The panels would be secured to the arm rest frame using velcro such that the arms can still be flipped back without having to remove the panels. Once the dimensions for the armrest are received sketches would be created in Inkscape to be laser cut using  $\frac{1}{4}$  inch black acrylic sheets.

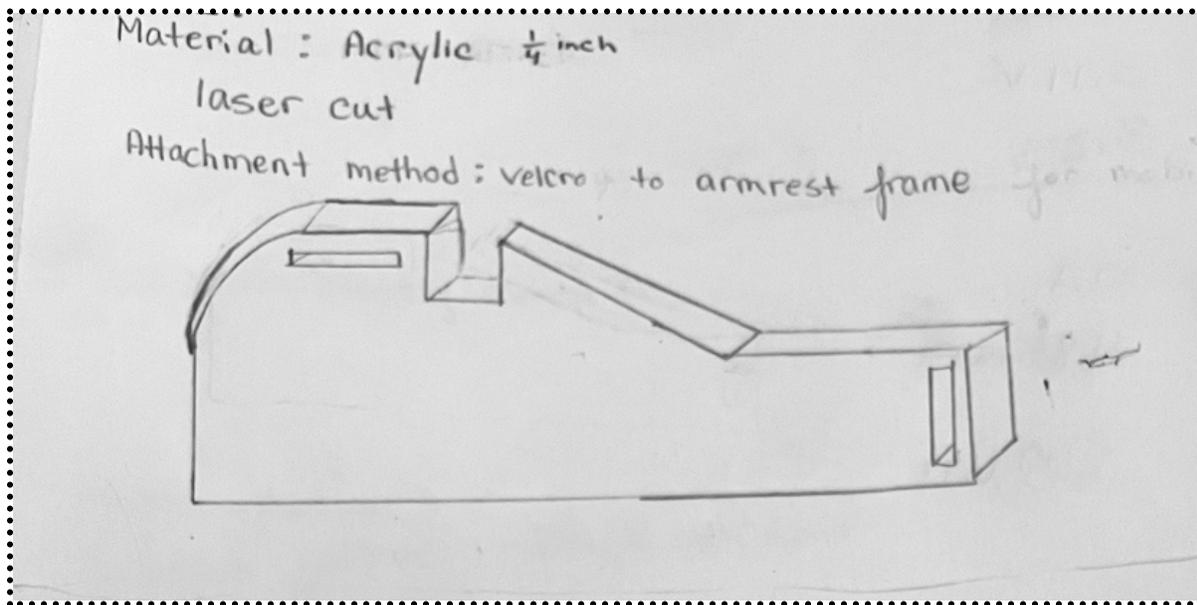


Figure 4. Ashley Design 1

**Design 2:**

The second proposed panel is a rectangular panel that would be tied to the frame of the armrest and sit on the inside of the existing panel.

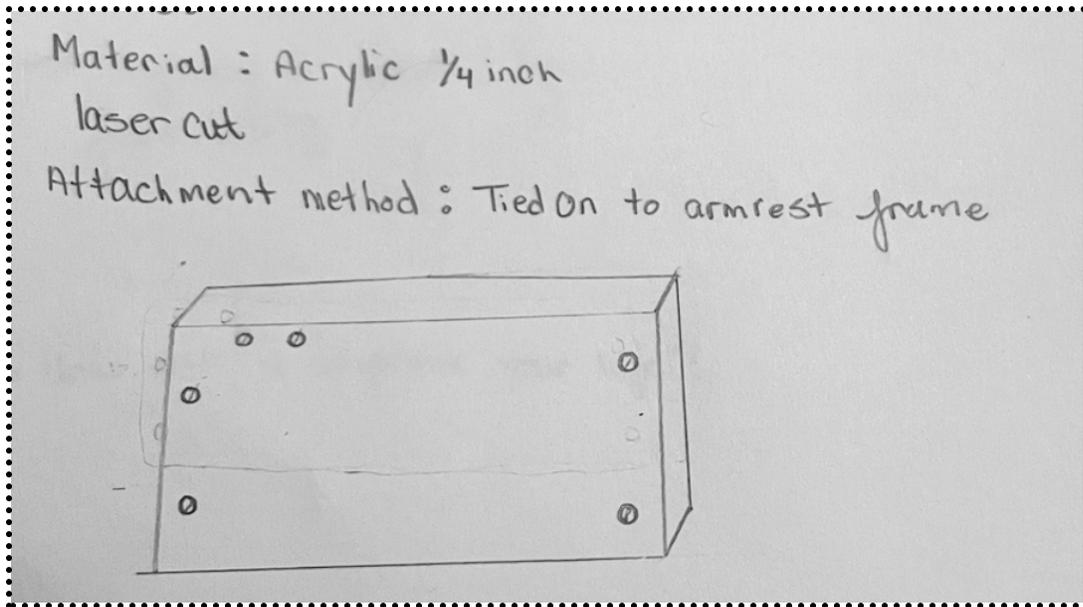


Figure 5. Ashley Design 2

**Design 3:**

The third proposed panel is shaped to sit against the existing panel on the armrest. It would be velcroed to the frame of the armrest. The design would be 3D printed or converted to an Inkscape sketch to be laser printed.

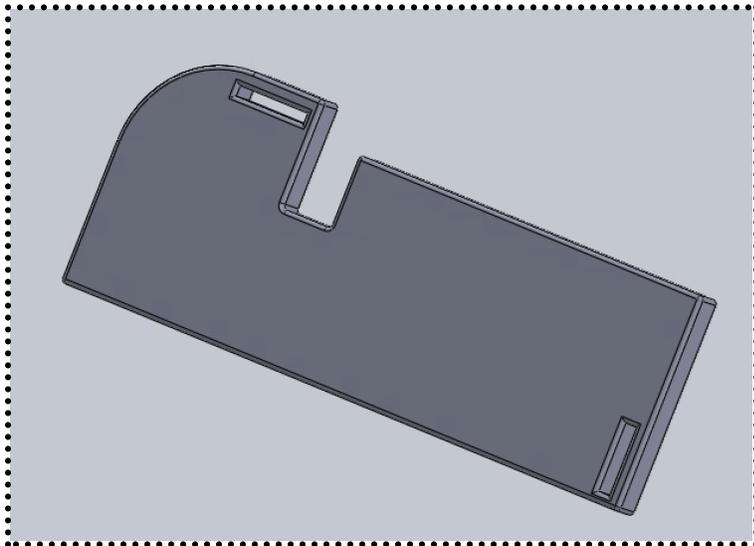


Figure 6. Ashley Design 3

### 4.1.2 Rasheek

All the sketches below display the side view of the armrest gaps of the wheelchair. They all display an attachment, stabilization and removal method which cover the main functionality of the product that needs to be made.

#### Design 1:

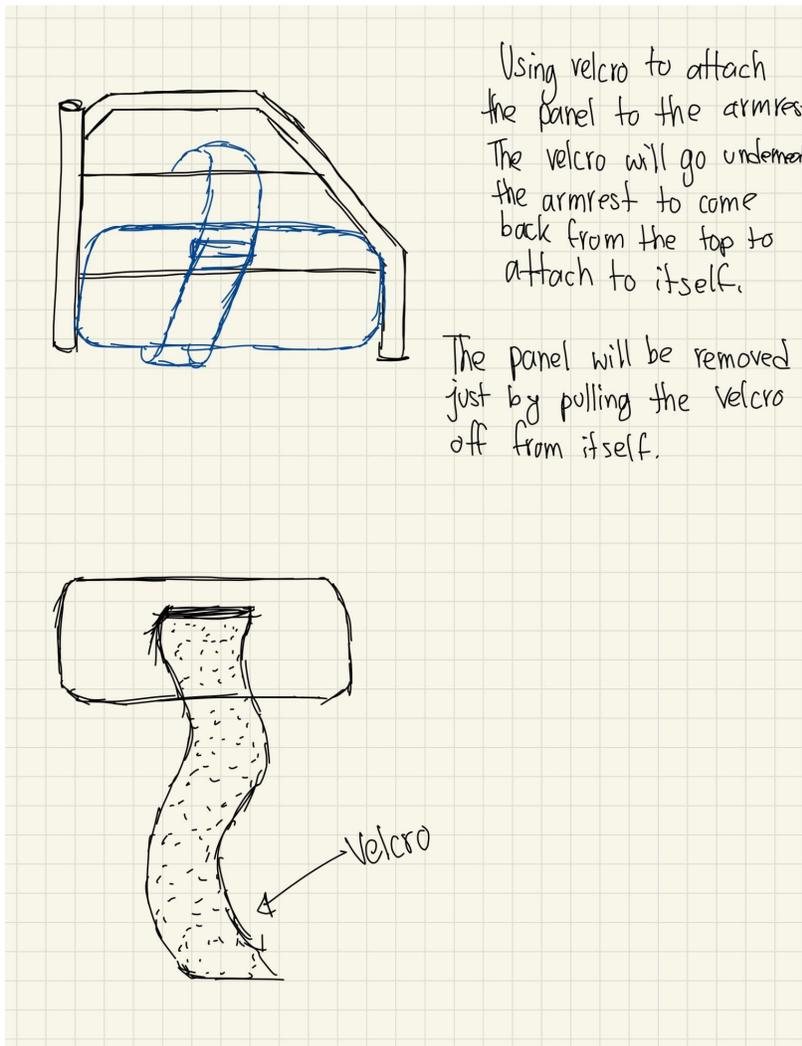


Figure 7. Rasheek Design 1

**Design 2:**

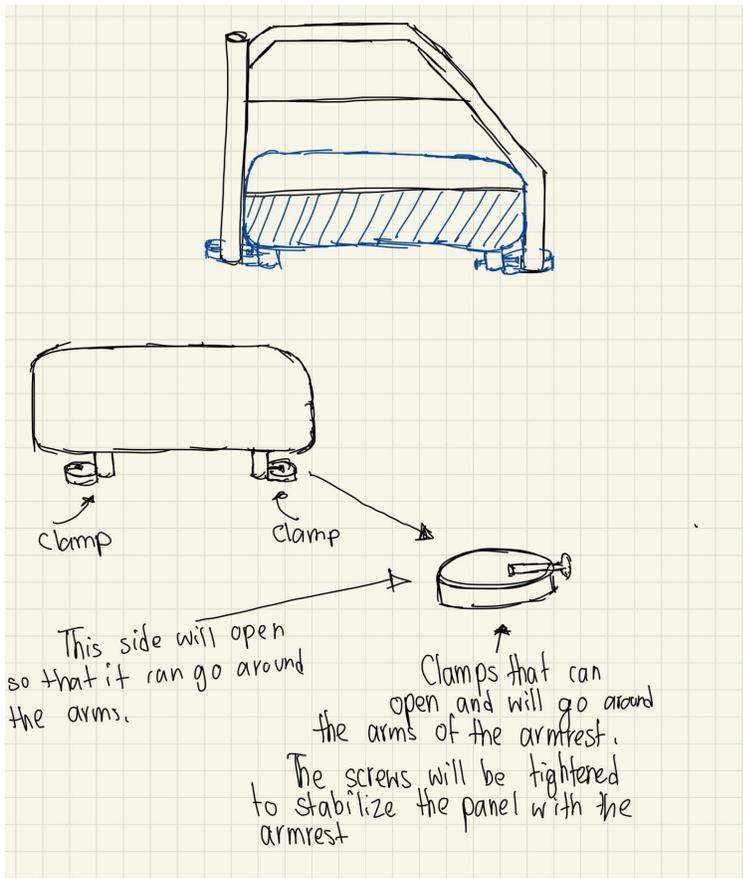


Figure 8. Rasheek Design 2

**Design 3:**

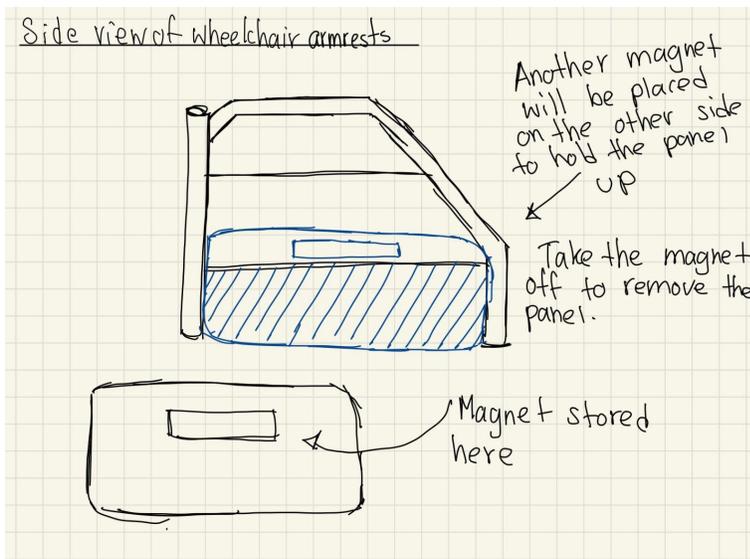


Figure 9. Rasheek Design 3

## 4.1.3 Jason

## Design 1:

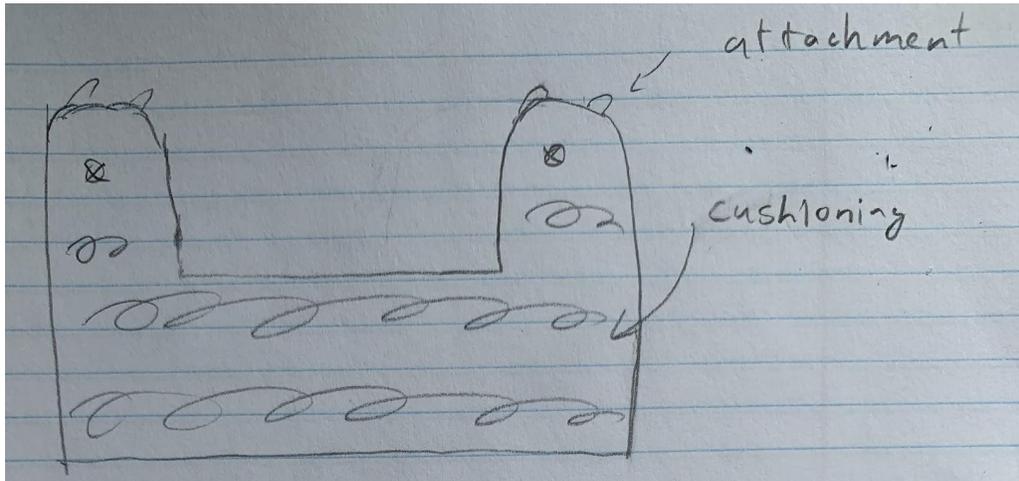


Figure 10. Jason Design 1

## Design 2:

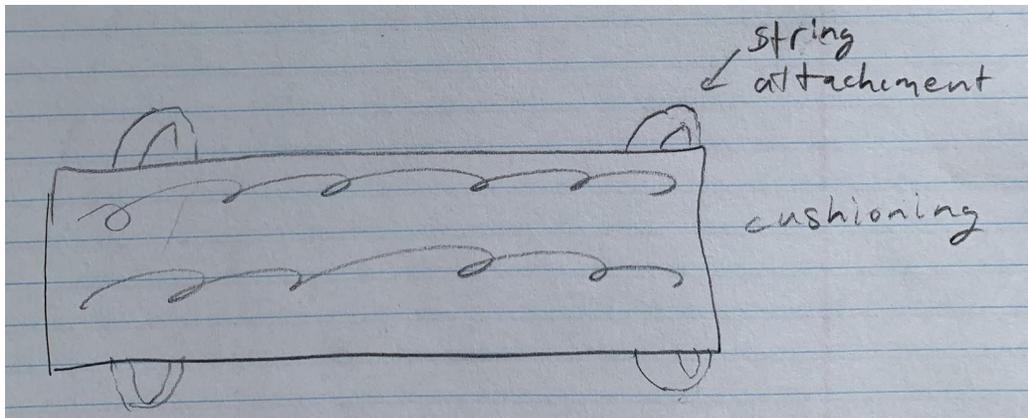


Figure 11. Jason Design 2

## Design 3:

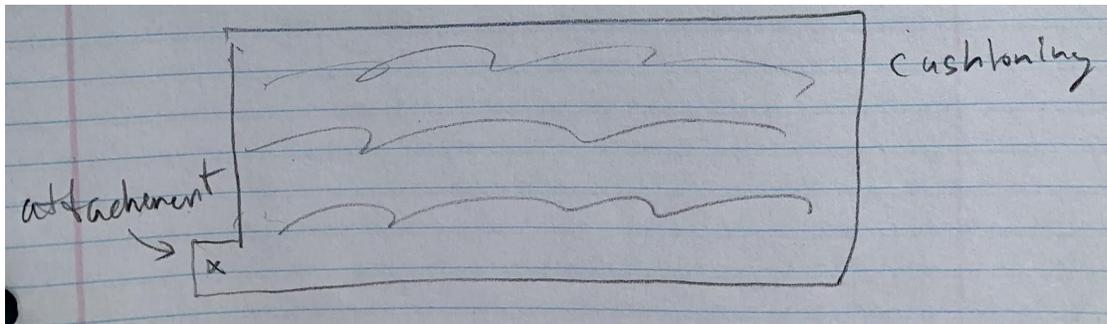


Figure 12. Jason Design 3

## 4.1.4 Ines

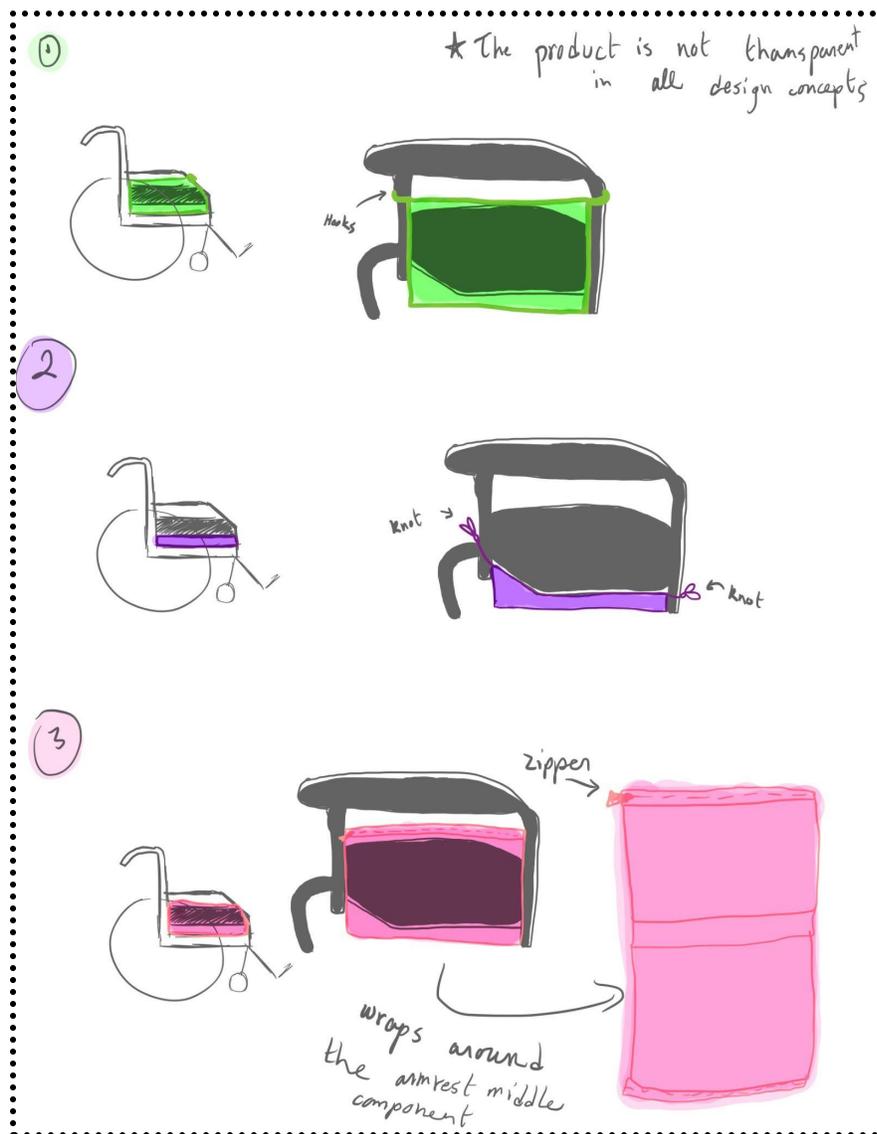


Figure 13. Ines' Designs

**Design 1:** The product is a hard and rigid material composed of hooks that wrap around the armrest. It is wide enough to cover all the length of the armrest and high enough to almost reach the top of the armrest.

**Design 2:** The product is a hard and rigid material that has two holes for strong laces to tie around the armrest sides. It is low to cover only the bottom arm gaps of the wheelchair and wide enough that it covers the length of it.

**Design 3:** Two hard rigid materials that are attached at the bottom by a flexible material and join at the top by a zipper. The product wraps around the middle component of the armrest and is attached by the zipper at the top. It is wide and reaches from the bottom to the top of the middle component.

## 4.1.5 Joseph

## Design 1:

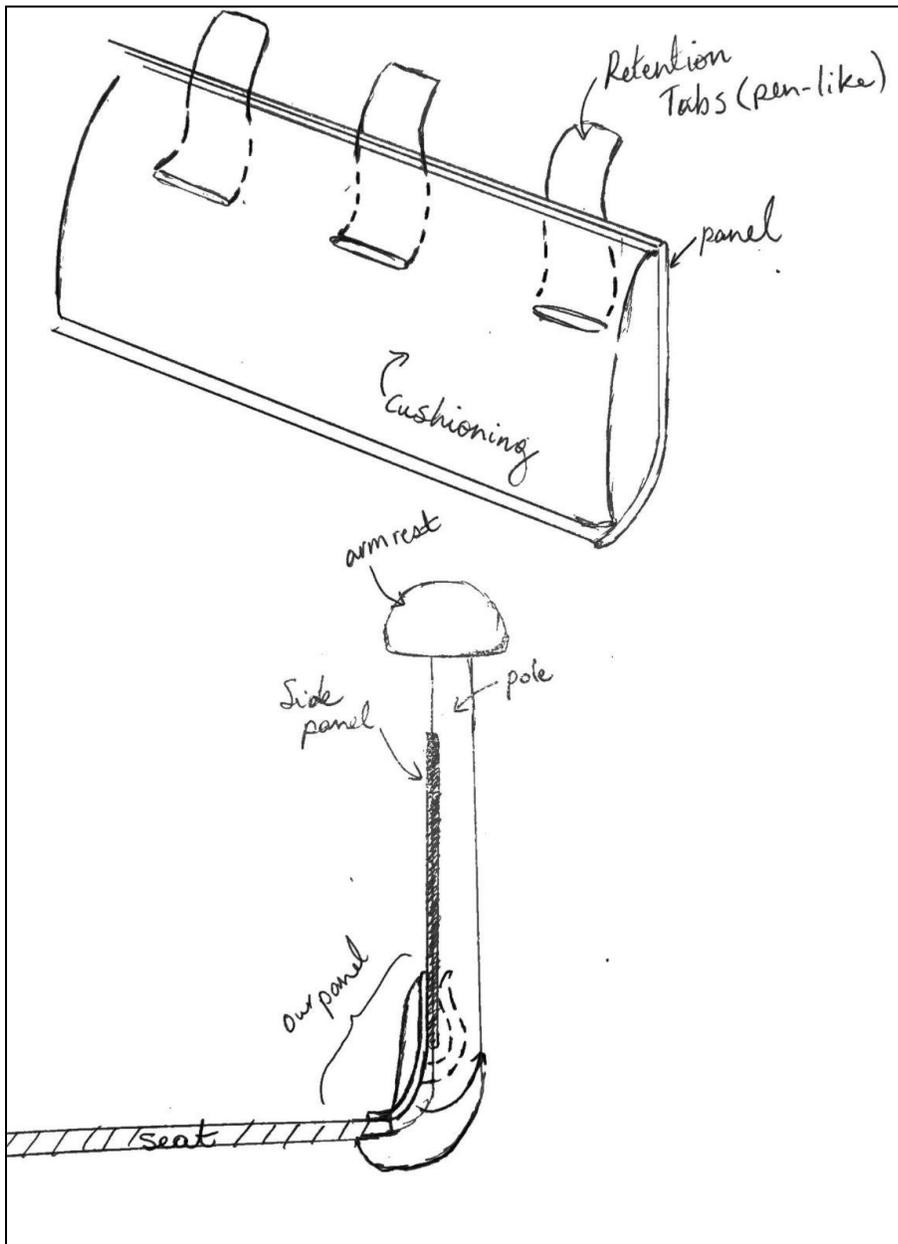


Figure 14. Joseph Design 1

This design uses pen-like tabs to keep the panel attached to the metallic side of the wheelchair.

Design 2:

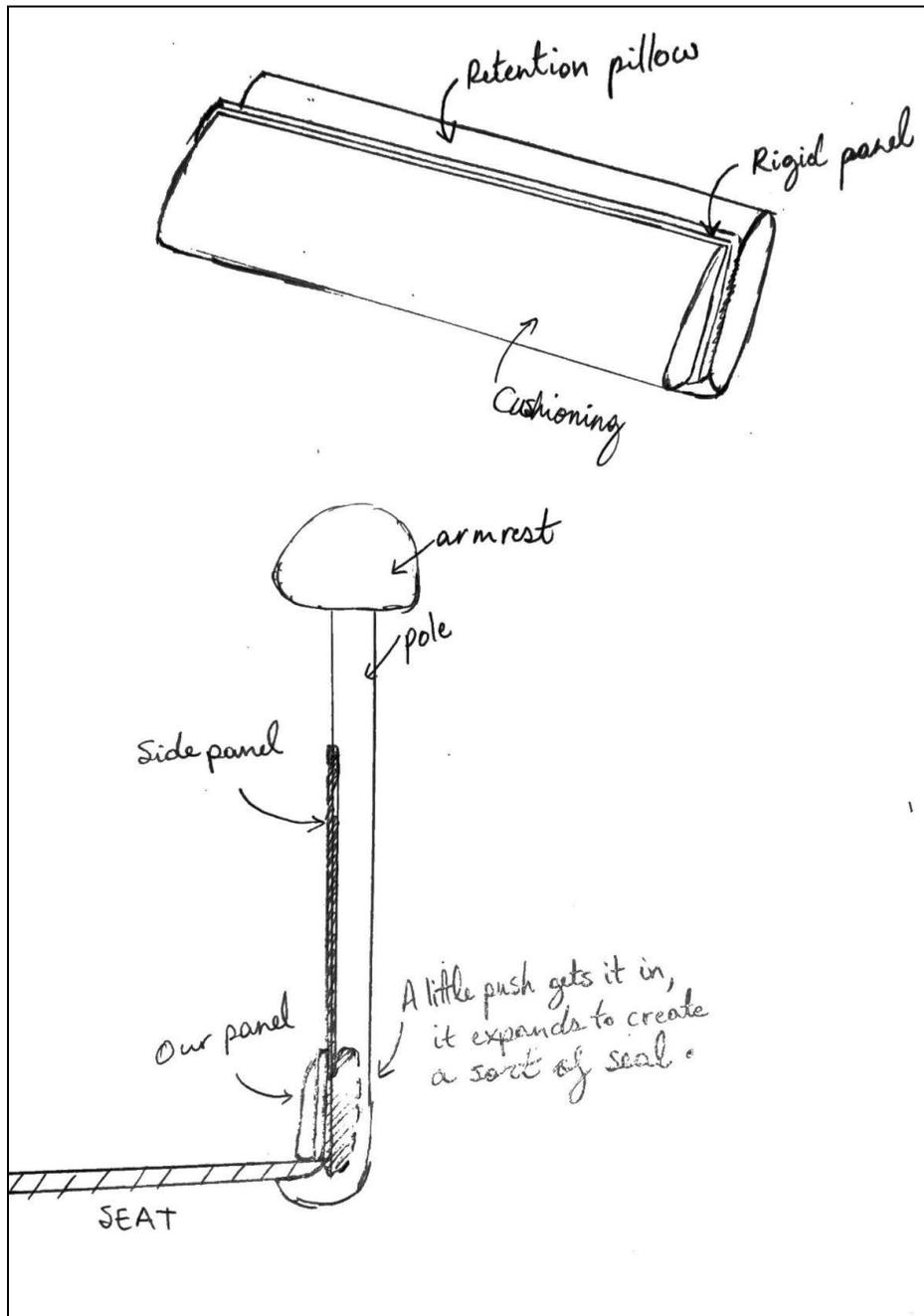
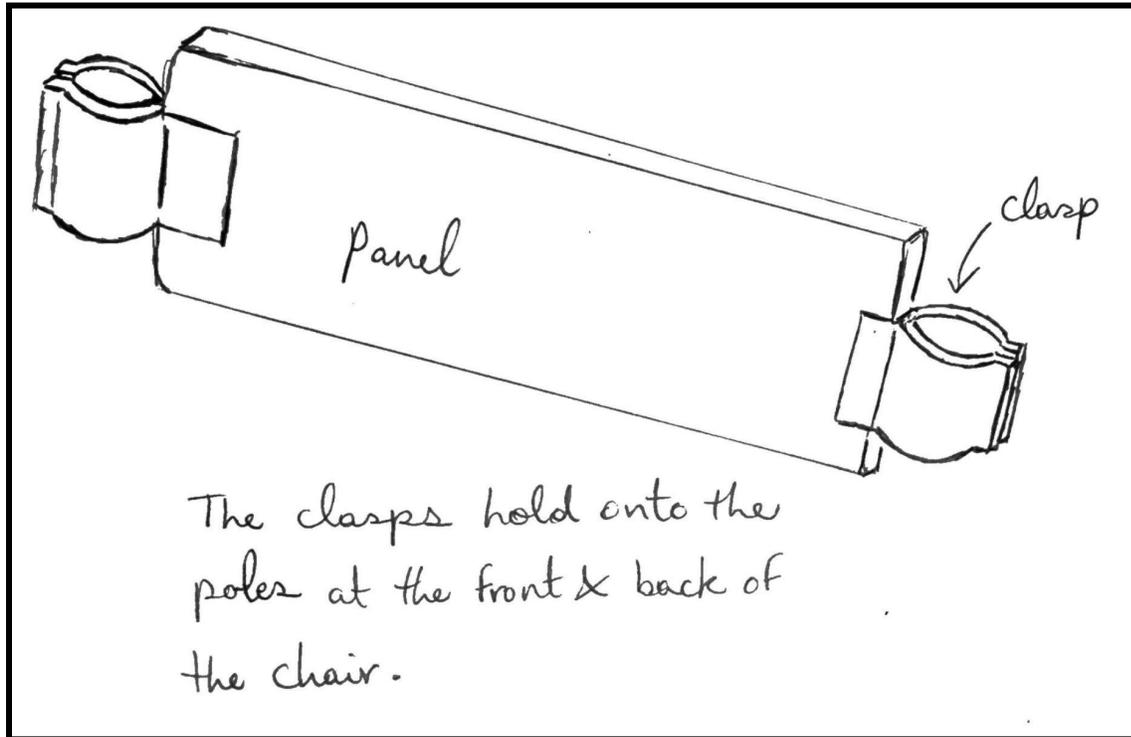


Figure 15. Joseph Design 2

This second design leverages the malleability of a cushion to create a seal that only becomes effective once it has been force-fitted into the gap.

Design 3:



*Figure 16. Joseph Design 3*

Finally, this third design holds onto the chair using clasps, much like the mechanism behind a microphone stand, which wrap around the pole-like structures at the front and back of the wheelchair's armrest.

## 4.2. Analysis & Evaluation of Concepts

Each proposed design was ranked based on the criteria outlined in [Table 5](#), annexed below. Each metric was assigned a weight based on the importance to the client also defined in Table 5. The score of each design was calculated by taking the summation of each weight multiplied by the score (1 to 5, depending on how well the requirement is met) in each category, and dividing the total by 100, to obtain an average score between 1 and 5.

*Table 1. Weighted Decision Matrices for Design 1 of each group member*

<b>Concept Options</b>						
<b>Selection Criteria</b>	<b>Weight (%)</b>	<b>Ashley - Design 1</b>	<b>Rasheek - Design 1</b>	<b>Jason - Design 1</b>	<b>Ines - Design 1</b>	<b>Joseph - Design 1</b>
Aesthetics	10.4	4	2	1	2	3
Rigidity	17.2	5	4	4	5	4
Ease to install	17.2	5	3	3	2	5
Comfortability	17.2	2	3	1	2	3
Water resistance	10.4	5	3	3	4	2
Thickness	13.8	4	3	1	2	1
Durability	13.8	3	2	3	2	1
<b>Total Score</b>		3.97	2.93	2.28	2.72	2.86

*Table 2. Weighted Decision Matrices for Design 2 of each group member*

Concept Options						
Selection Criteria	Weight (%)	Ashley - Design 2	Rasheek - Design 2	Jason - Design 2	Ines - Design 2	Joseph - Design 2
Aesthetics	10.4	1	2	2	2	3
Rigidity	17.2	4	5	3	3	4
Ease to install	17.2	5	1	3	3	5
Comfortability	17.2	1	3	4	3	4
Water resistance	10.4	5	3	1	4	2
Thickness	13.8	3	3	1	2	2
Durability	13.8	3	2	2	2	3
<b>Total Score</b>		2.35	2.76	2.28	2.72	3.45

*Table 3. Weighted Decision Matrices for Design 3 of each group member*

Concept Options						
Selection Criteria	Weight (%)	Ashley - Design 3	Rasheek - Design 3	Jason - Design 3	Ines - Design 3	Joseph - Design 3
Aesthetics	10.4	2	3	2	2	3
Rigidity	17.2	5	2	3	4	4
Ease to install	17.2	5	4	3	1	3
Comfortability	17.2	2	3	4	3	4
Water resistance	10.4	4	3	1	3	2
Thickness	13.8	2	3	1	2	2
Durability	13.8	2	2	2	3	3
<b>Total Score</b>		3.24	2.86	2.28	2.59	3.10

### 4.3 Promising Solutions

We can see from the scores, calculated in the previous section, that certain designs are rather promising. With a score of 3.97, Ashley's first design stands at the top, being the one most able to meet the design criteria set out by the team. As such, it will constitute the base of the final design, with elements from other designs integrated according to their strengths and relative feasibility.

In comparison to other designs, Ashley's lacked with regards to its comfortability. To remedy this, we will incorporate from other designs, such as Joseph's second concept, the idea of including a layer of padding on the inside face of the panel.

Ashley's design also has a slight disadvantage in that its limited use of fastening mechanisms (only two velcro straps) makes it inherently less stable than other designs. To fix this, we will incorporate an additional strap on the back, such that there is now a stabilizing form in 3 different locations, an idea loosely borrowed from Ines' second design. We may also opt to fasten using clasping rings around the armrest frame, an idea borrowing from Rasheek's second design.

### 4.4 Group Design Concept

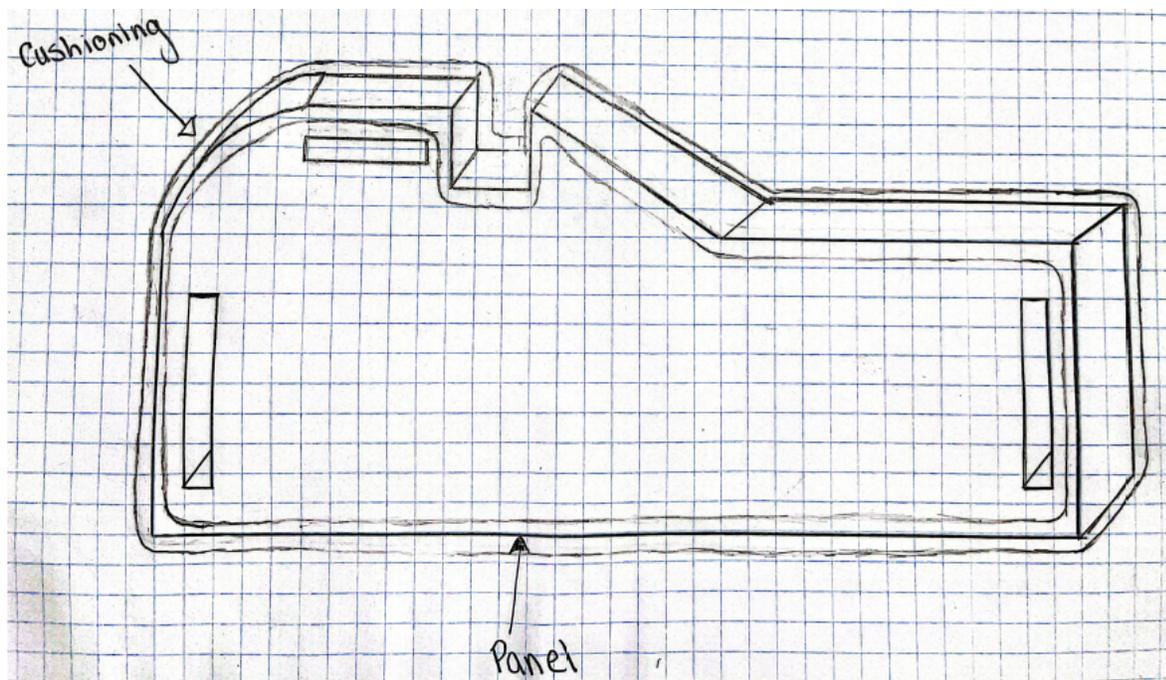


Figure 17. Final Group Design

The final agreed upon design consists of a rigid panel that is shaped to fit underneath the existing panel on the flip-back arms installed on the client's wheelchair. The panel will have three small openings to feed the velcro through and attach to the frame of the armrest for easy installation. The panel will be laser cut from  $\frac{1}{4}$  inch acrylic sheets to make sure that the panels are not too wide making the chair uncomfortable for the user. The panels will be covered with cushioning and water resistant fabric to ensure they are durable and comfortable throughout the clients daily activities.

The final group concept will be altered in the future if it is found that another attachment method would be more suitable, as mentioned within the promising solutions. More information is required from the manufacturer before final design sketches can be created.

One potential drawback of this design is the degree to which the velcro straps can be tightened. This is being mitigated by adding an additional velcro connection to the front of the panel and the fastening will be tested in the early stages of prototyping to allow time for improvements. Another possible drawback of this design is the aesthetics, the panel is awkwardly shaped to fit inside the frame of the chair but this is being mitigated by using black fabric to match the clients wheelchair. All potential drawbacks will be discussed with the client in future meetings so appropriate changes can be made.

## 5. Conclusion

Using the problem statement and list of identified client needs from Deliverable B, each group member has submitted possible solutions to fill the gaps underneath the client's wheelchair armrests. Using the proposed concepts, a group design concept has been created that most optimally meets the specified design criteria. The final design includes a rigid panel that will be cushioned and covered in a black, water-resistant fabric. The method of attachment will be velcro straps to the frame of the armrests, so that the panels can move along with the arms when they are flipped back.

The group design concept is subject to change, once feedback is received from the client. The final specifications of the design will be outlined in Deliverable D, the detailed design and bill of materials. Additionally, there will be another meeting with the client on October 3<sup>rd</sup>, 2022 to address the possible drawbacks of the current group design.

## 6. Annex

*Table 4. Client Statements and Interpreted Needs*

#	Client Statement	Interpreted Need	Importance*
1	I want the gaps to be covered	The panels fully close the side gaps.	5
2	The panels should be “stiff”	The panels are rigid.	5
3	The panel must not interfere with the wheel	The panels are flat.	4
4	The panels should not make the chair any wider.	The panels face inward. The panels are thin.	5
5	The panels should be as easy as possible to install.	The panels are easy to install for a lone user	4
6	The panels should match the rest of the chair.	The panels are black.	1
7	The panels need to resist the weather (Gardening).	The panels are waterproof. The arm gap panels need to withstand shock.	4
8	The arm rest should still be able to flip back.	The arm gap panels need to move with the armrests	3

*\*importance rating 1-5; 5 being most important, 1 being least important.*

Table 5. Metrics

Metric #	Need #	Metric	Functional/Non Functional	Importance	Units
1	6	Aesthetics	Non Functional	3	Subj
2	3, 4	Flatness	Functional	5	Yes/No (Binary)
3	5	Ease to install	Non Functional	5	Subj
4	7	Comfortability	Functional	5	Subj
5	7	Waterproof	Functional	3	Yes/No (Binary)
6	4	Thickness	Functional	4	in
7	7	Durability	Functional	4	Years
8	N/A	Cost	Non Functional	1	\$CDN
9	2	Rigidity	Functional	5	Subj

*\*importance rating 1-5; 5 being most important, 1 being least important.*

Table 6. Target Specifications

Metric #	Metric	Unit	Marginal Value	Ideal Value
1	Aesthetics	Subj	Any color	Black
2	Flatness	Binary	Yes	Yes
3	Ease to install	Subj	Moderate ease	With ease
4	Comfortability	Subj	Comfortable	Very Comfortable
5	Water resistance	Binary	No	Yes
6	Thickness	in	< 1.5	< 7/8
7	Durability	years	>3	>5
8	Cost	\$CDN	<50	<30
9	Rigidity	Subj	A bit of flex	No flex at all