IB DP Design Technology Internal Assessment:

The “EZ-Fold” Chair

Word Count: 1718

Criterion A.1: **Design Opportunity**

Putting on shoes is a daily task executed by many, and one that not much thought is put into; but for elderly individuals with physical limitations, that simple task is a daunting one. Bending of the hips, leg muscle, and advanced balance are some things needed to put on a shoe safely and properly, much of which the elderly population does not have. As the population of elderly individuals increases in Korea, a need for solutions that encourage elderly independence is more prevalent than ever.

The Problem

User's balance is heavily reliant on wall. When balancing on one leg, it is necessary to hold on to something; this is a problem in itself, as the arms of the user is not reliable.

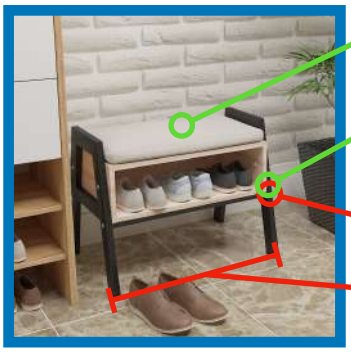
Lifting a leg is required when putting on shoes, resulting in the other leg experiencing a lot of stress and force. This detrimental to the leg and also a safety concern.

Shoe is **difficult to put on properly** due to lack of control from user's arm and large distance between the user and the shoe.

The **limited space** of doorways in common Korean apartments greatly restrict the use of alternative solutions, such as placing a chair to sit on when putting on shoes. Most doorways consist of a 120 by 140 cm rectangular area. [Appendix A.2.2]

Existing Products [Appendix A.1.5]

Cons | Pros



Sitting makes the process of putting on shoes a lot easier [Appendix A.2.4]

The height of the chair is not high, reducing the amount of bending that is needed

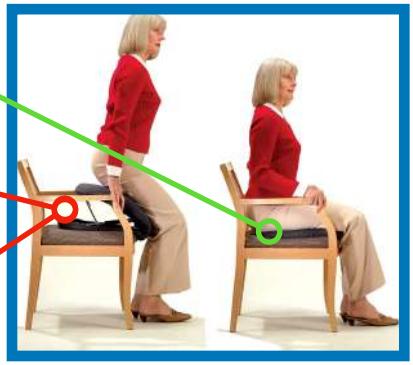
Low height makes sitting and standing up difficult

Space the seat occupies is unsuitable for smaller Korean apartments.

Sitting and standing easier by soft seating and standing assistance

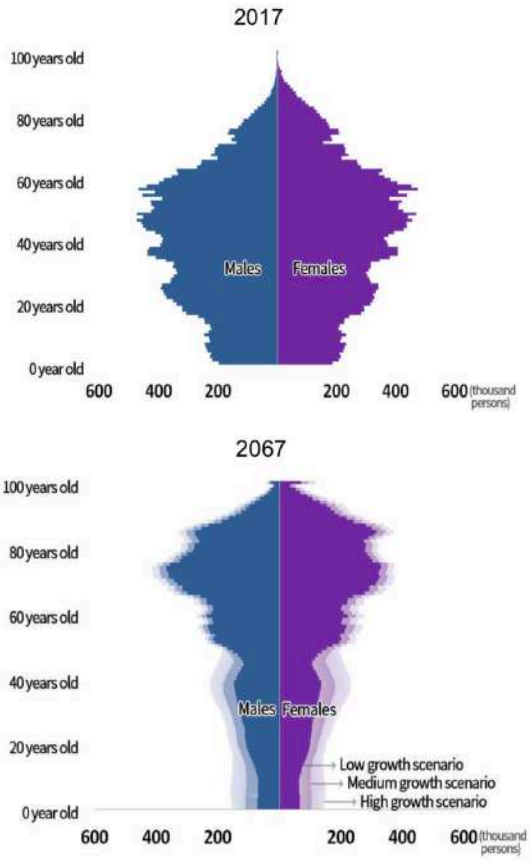
Lift height not high enough to assist someone short chairs

Angle is too small to assist someone on short chairs



Market: Population increase

Elderly individuals, in 2017, make up 13.8% of the population of South Korea. It is projected that number to increase unto 45.6% by 2067, making it 5.7 times higher than the child population.[Appendix A.2.1]



Criterion A.2: **Design Brief**

In a broad sense, the product will be some kind of space-efficient chair with optimal dimensions for putting on shoes that is easy to get on and get off. This will tackle the different main aspects of the problem: limited space and limited physical functions of the user. Because the product is one that is heavily reliant on physical interaction with the users, the prototype for the design will have to be of high fidelity. The chair will be used a few times a day, completely dependent on the user.

Personae of User [Appendix A.2.4]

User	Characteristics

	• Elderly
	  ○ Age of 65 or more [To be identified as elderly in Korea, must be 65 or more]
	• Physical limitations
	  ○ Leg strength and movement
	  ○ Hip movement and flexibility
	  ○ Lower back strain
	  ○ Balance
	  ○ Supporting muscles
	• Lives in an Apartment
	  ○ Small doorway
	  ○ Limited Space

Design Briefs

- Must have a seating area
- Must feel safe and stable sitting on it
- Must be space efficient
  - Must be against the wall
- Must assist the user in sitting down and standing up
- Must minimize movement of user when putting on shoes
- Must be simple
  - Simple to use
  - Aesthetically simple

Anthropometric Data [Appendix A.2.3]

Data	Description and Justification
Weight 	Needs to be able to support the user's weight and feel stable. **99th Percentile** ~100 kilograms
Sitting Popliteal Depth 	Must have a right depth for a safe-feeling seating **25th Percentile** ~450cm
Sitting Hip Width 	Should have a seating area that is wide enough for comfortable seating. **75th Percentile** ~380cm
Sitting Popliteal Height 	Must make the bending of the torso the the minimum and it must be comfortable to sit on. **25th Percentile** ~370cm
Groin Height 	Needs to be able to provide a comfortable and safe sitting/standing process, which the groin height helps figure out. **75th Percentile** ~750cm

Client Interview [Appendix A.1.3, A.2.4]

When interviewing client that fit the target audience, Elderly individuals, especially those with physical disabilities, have mentioned their difficult time with putting on shoes. As people age, performing daily actions becomes more and more difficult. The main reason for this is sarcopenia, which is the loss of skeletal muscle tissue with mass.

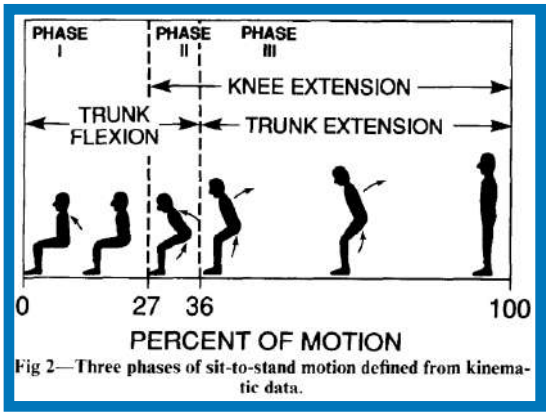
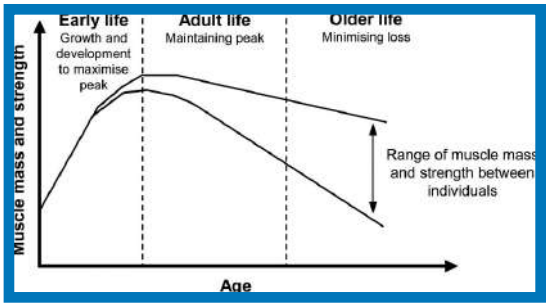


Fig 2—Three phases of sit-to-stand motion defined from kinematic data.



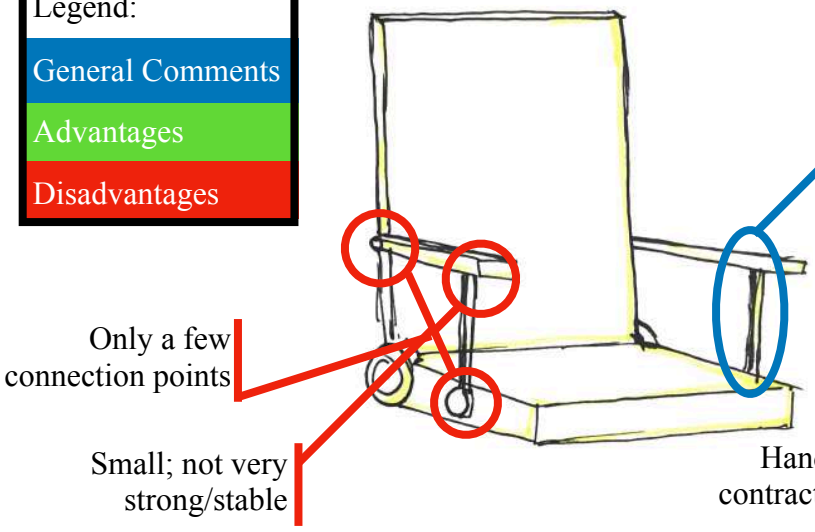
Criterion A.3: **Design Specifications**

Specification		Justification	Testing Strategy
1. Function	1.1 Must provide gentle landing when sitting	To prevent any physical harm to the user, the seat should have a mechanism that decreases the impact the chair has on the user when sitting down. As the chair is going to have a foldable function, it can be used to its advantage by slowing down its falling rate.	User Interviews User Trials Expert Trials
	1.2 Must push up and help the user when getting up from seat	It has been made clear from the client interview and preliminary research that standing up from a sit-in position is difficult. [Appendix A.2.6] The chair will assist standing up by giving the user a little much from below.	
	1.3 Must be stable; no rocking or unintended movement	From the client interview [Appendix A. 2.6], it was clear that sitting and standing up involved a lot of maneuvering and imperfect motions. This means that the product needs to be sturdy to ensure safety of the user and	
2. Size	2.1 The height of the seating area much be optimized for tying shoes	User interview identified that sitting is the safest and comfortable method of putting on shoes. [Appendix A.2.6] To take full advantage of this, the optimal height will be determined with anthropometric data [Appendix A.2.3]	User Trials Field Testing
	2.2 Must be foldable/retractable	User research showed that the doorway area is very small for Korean apartments. [Appendix A.2.1/A.2.2] Making the product foldable and retractable should help with saving space.	
3. Aesthetics	3.1 Must be simplistic	There is not need nor preference for specific aesthetics, but it has been mentioned in the interview that elderly are not the best at getting adjusted to new technology. Therefore the product being simple will help the user get used to the usage of the product a lot more.	User Trials User Interviews
4. Materials	4.1 Must have vital structure made up of steel or aluminum	They are strong, durable, and light weight; which are elements that are essential to ensure a safe and stable-feeling product. Not only that, but the material needs to be strong enough to be able to easily hold up 100kg. [Appendix A.2.3]	Field Testing User Interview Performance Testing

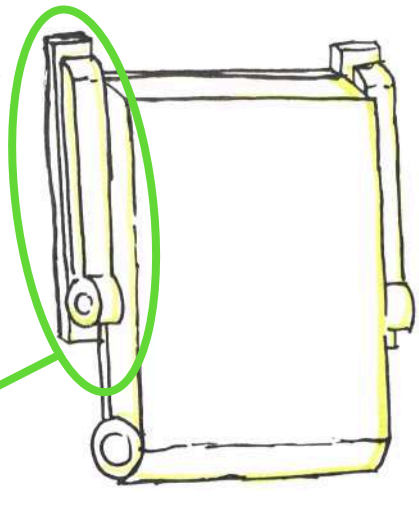
	4.2 Must have the seating area made up of ergonomically molded plastic	Much like workout materials, it ensures a comfortable and durable area to sit. Plastic is a right balance of flexibility and rigidity for a comfortable seat. Additionally plastic is easy to clean.	
5. Target Market/ Target Audience	5.1 Elderly Individuals	In the majority of appendix A.1, specifically appendix A.1.1~A.1.4, it has been established that the main target audience for this product is for the elderly. The need for elderly independence and increase in market potential lead to the conclusion. It can be expected for elderly individuals to purchase and use one for themselves in their own homes.	N/A
	5.2 Elderly Homes	Branching off specification 5.1, the product would be well used in an elderly home setting; a place where there are many potential users	
	5.3 Hospitals	There are many instances in hospitals when people are asked to take off shoes, including . Furthermore, there are many situation when people are asked to wait for a period of time. Having a chair that allows for sitting for a short period of time for those who have difficulty standing for a long time or even for those who are simply tired.	
6.Quantity	6.1 Only one full-scaled, fully-functioning prototype will be made	The product is somewhat complex and expensive to build, therefore only one prototype will be made. Instead, it will be one of high fidelity, functioning and scaled exactly how the final product would be.	N/A
7. Safety	7.1 Durability of the chair	The chair needs to be durable enough so that a person up to 100kg can sit on the chair and feel stable [Appendix A.2.3]	User Trials Field Testing
	7.2 Minimal Impact	To avoid any severe impact that may injure the user when sitting down, some mechanism should be implemented to soften the seating	

Criterion B.1: **Exploration of Ideas**

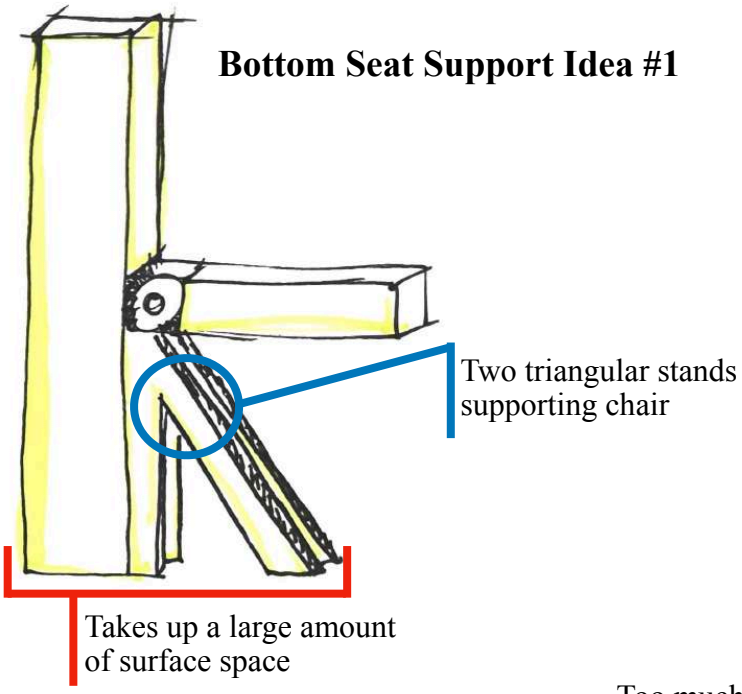
Legend:
- General Comments
- Advantages
- Disadvantages



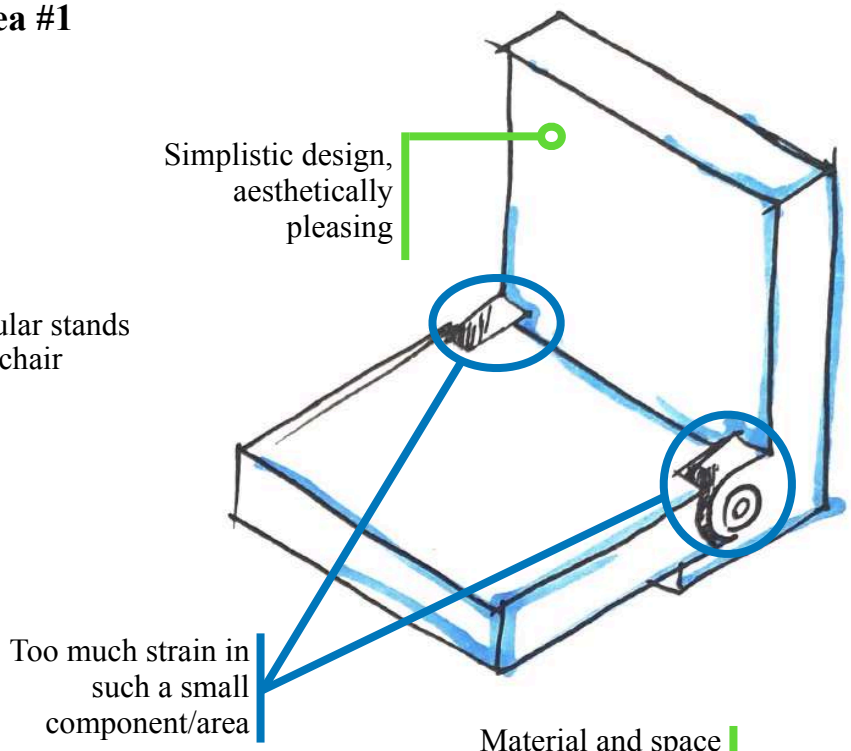
Armrest Mechanism Idea

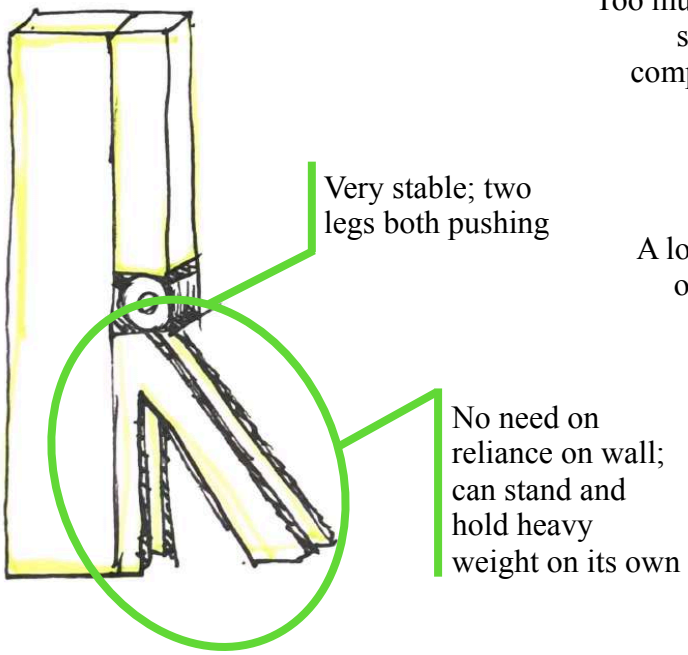


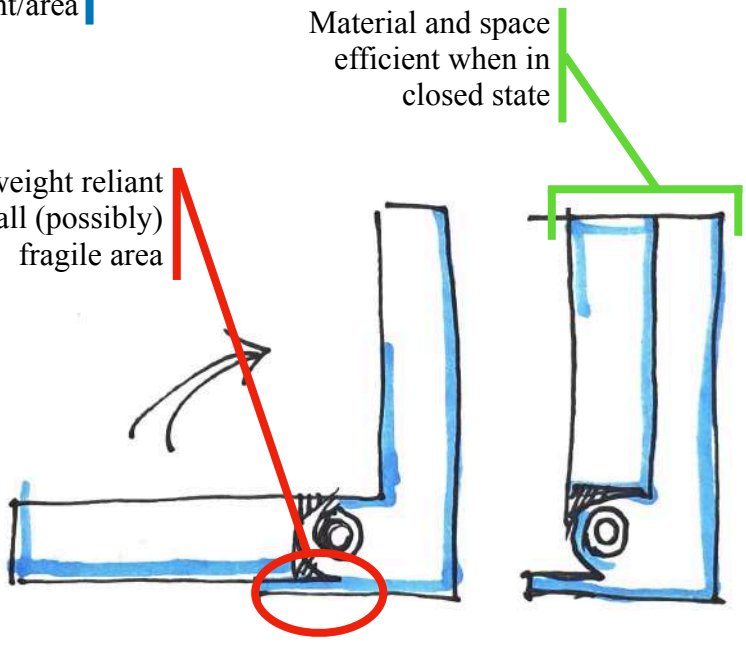
Bottom Seat Support Idea #1



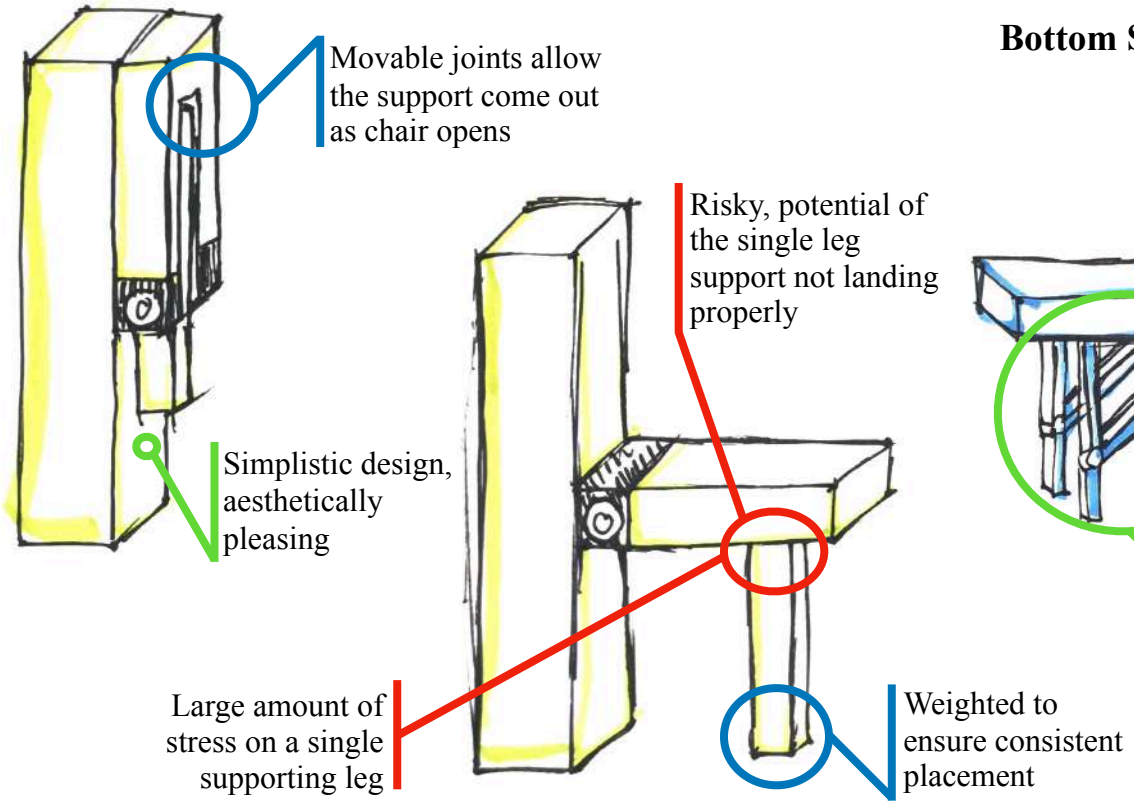
Bottom Seat Support Idea #2



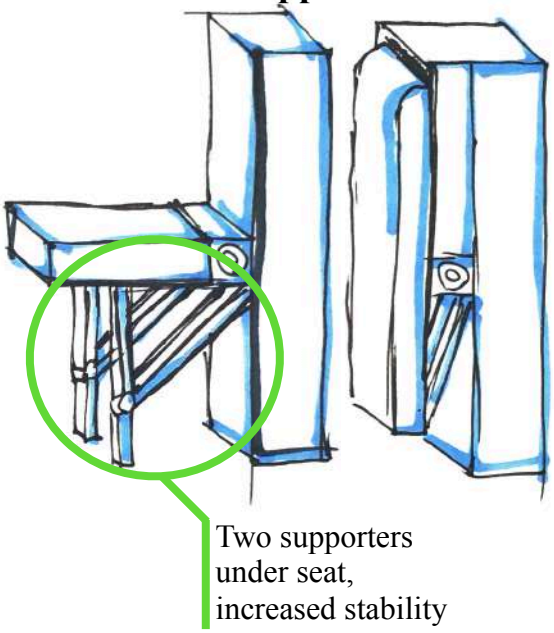




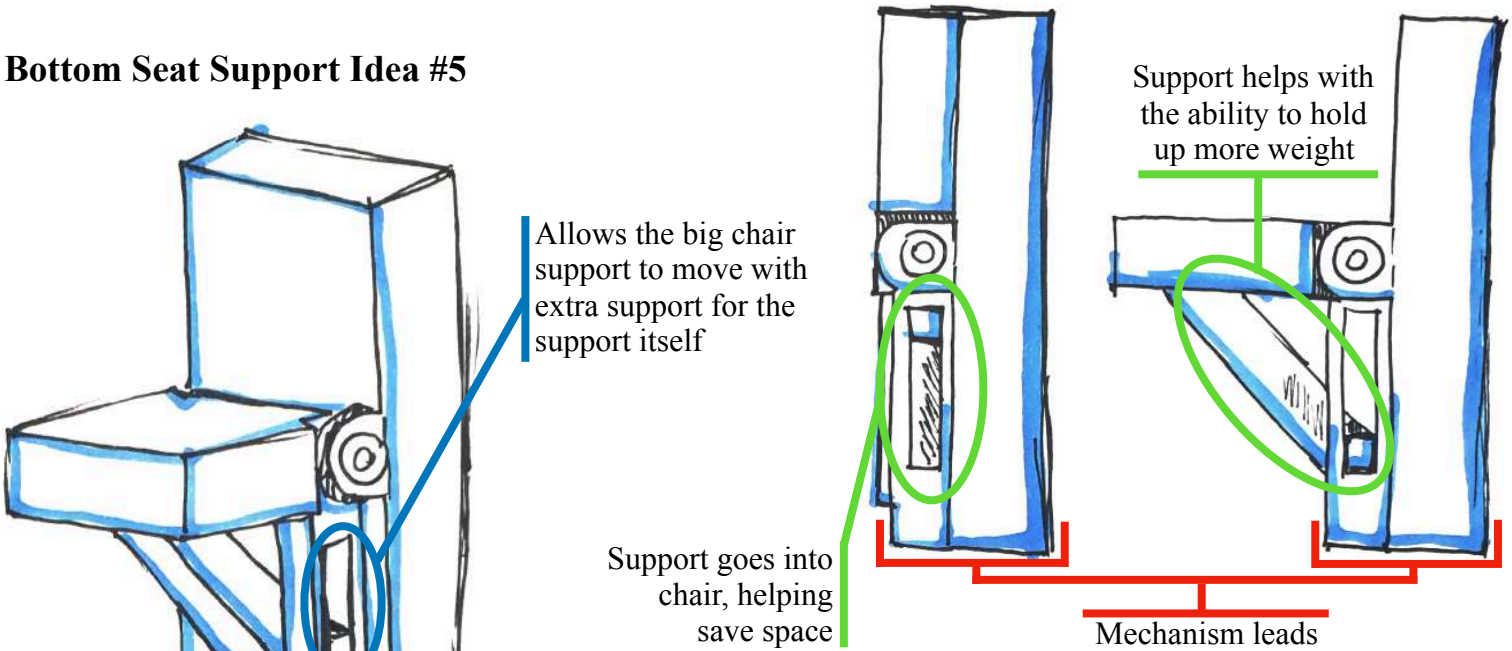
Bottom Seat Support Idea #3



Bottom Seat Support Idea #4

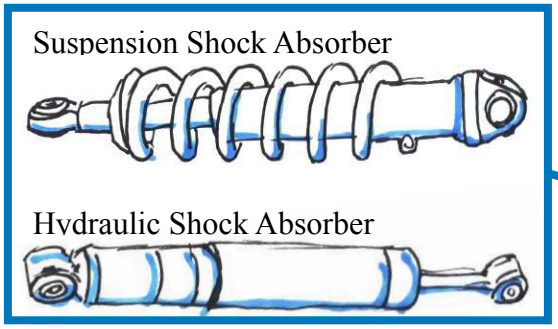


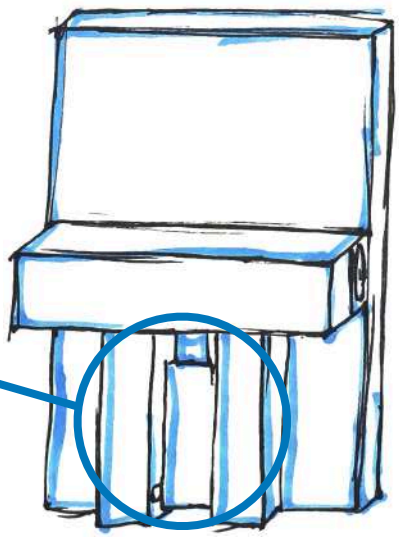
Bottom Seat Support Idea #5

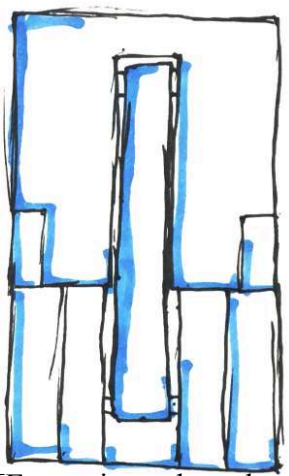


Reducing Impact

To minimize impact when sitting down, shock absorbers [Specification 7.2]





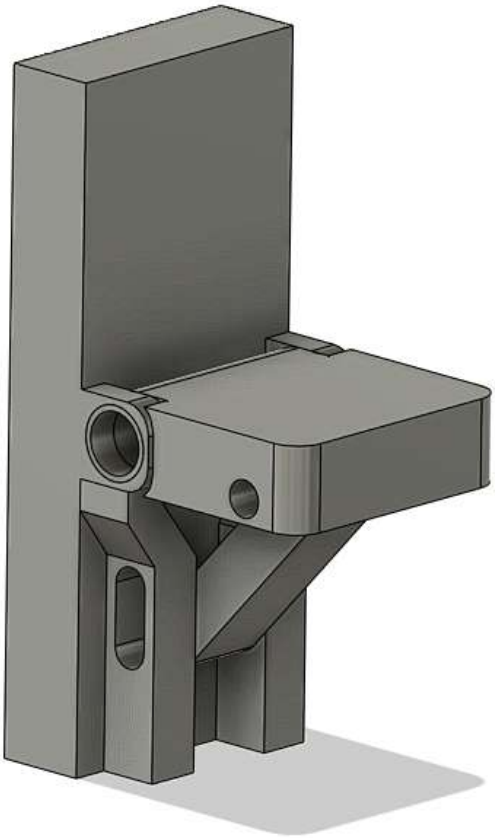


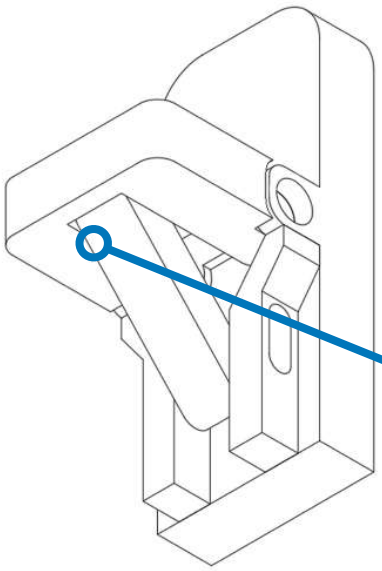
[Front view when closed]

Criterion B.2: **Development of Ideas**

CONCEPT DESIGN #1

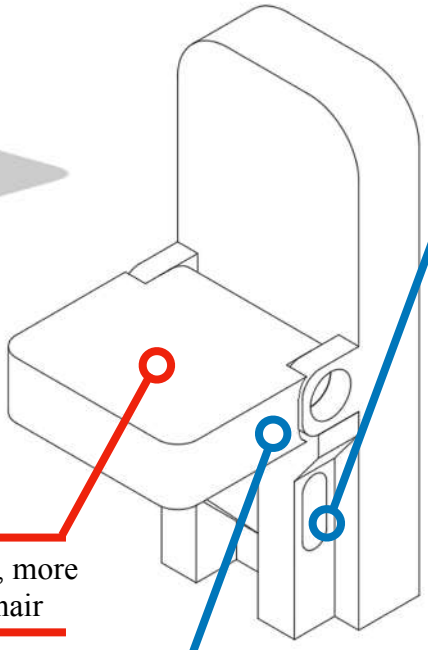
Legend:
- General Comments
- Advantages
- Disadvantages





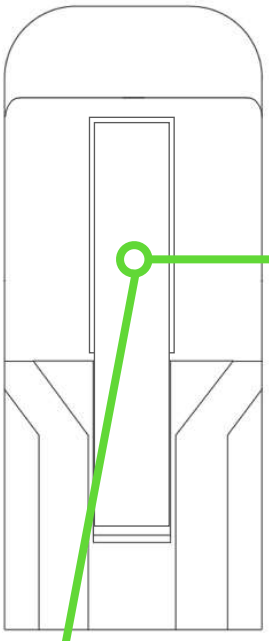
This section of the chair will be shock absorbers;

Reduce impact [Specification 7.2]



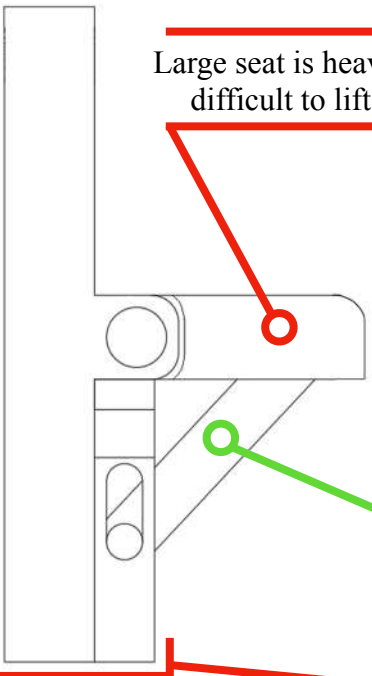
Gap acts as space for the support to move

[Front view when closed]



Large seat is heavy, more difficult to lift chair

Easy to use [Specification 7.2]



Diagonal support helps with stability and strength [Specification 1.3, 7.1]

Support retracted into the main body saving space [Specification 2.2]

Complexity of mechanisms result in thickness and bad space-efficiency

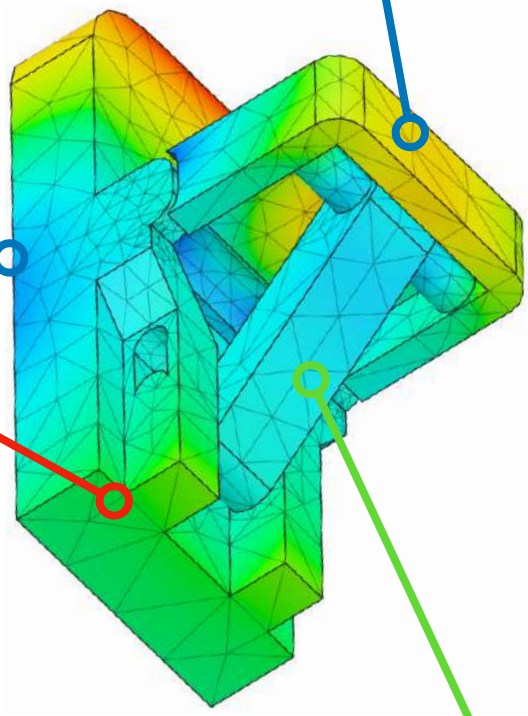
Requires more material due to larger size

Support retracted into the main body saving space [Specification 2.2]

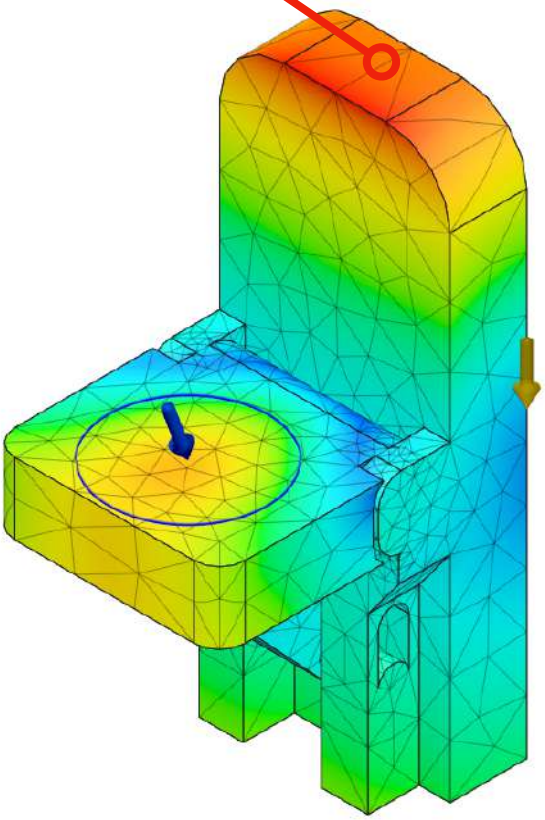
Displacement FEA

Edge has displacement, must use strong material

Face fixed to wall



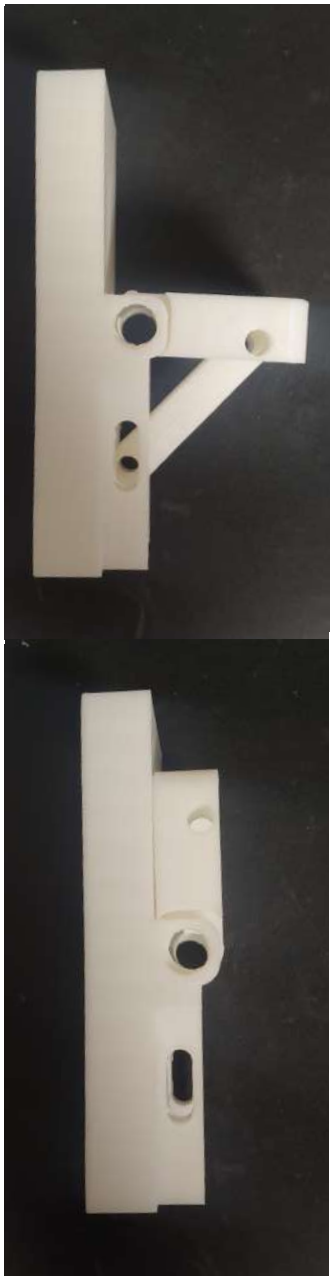
A lot of displacement on back rest due to gravity



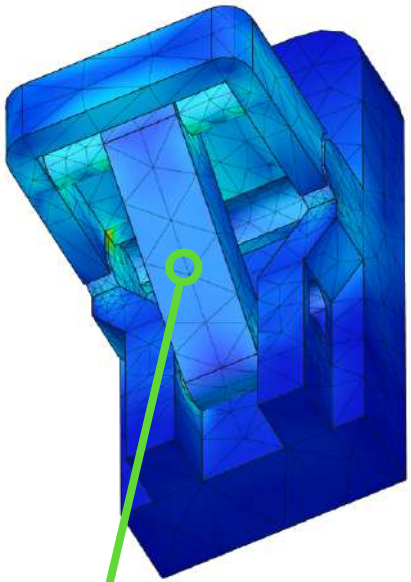
Bottom base of chair should stagnant

Support is stable and helps decrease displacement

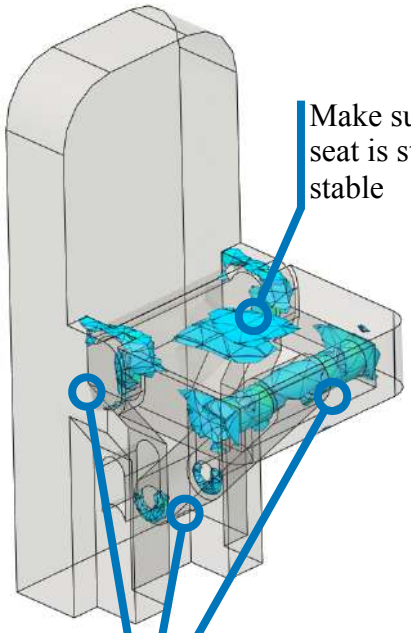
3D Printed Scaled Model



Stress FEA



Stress distributed relatively evenly throughout support

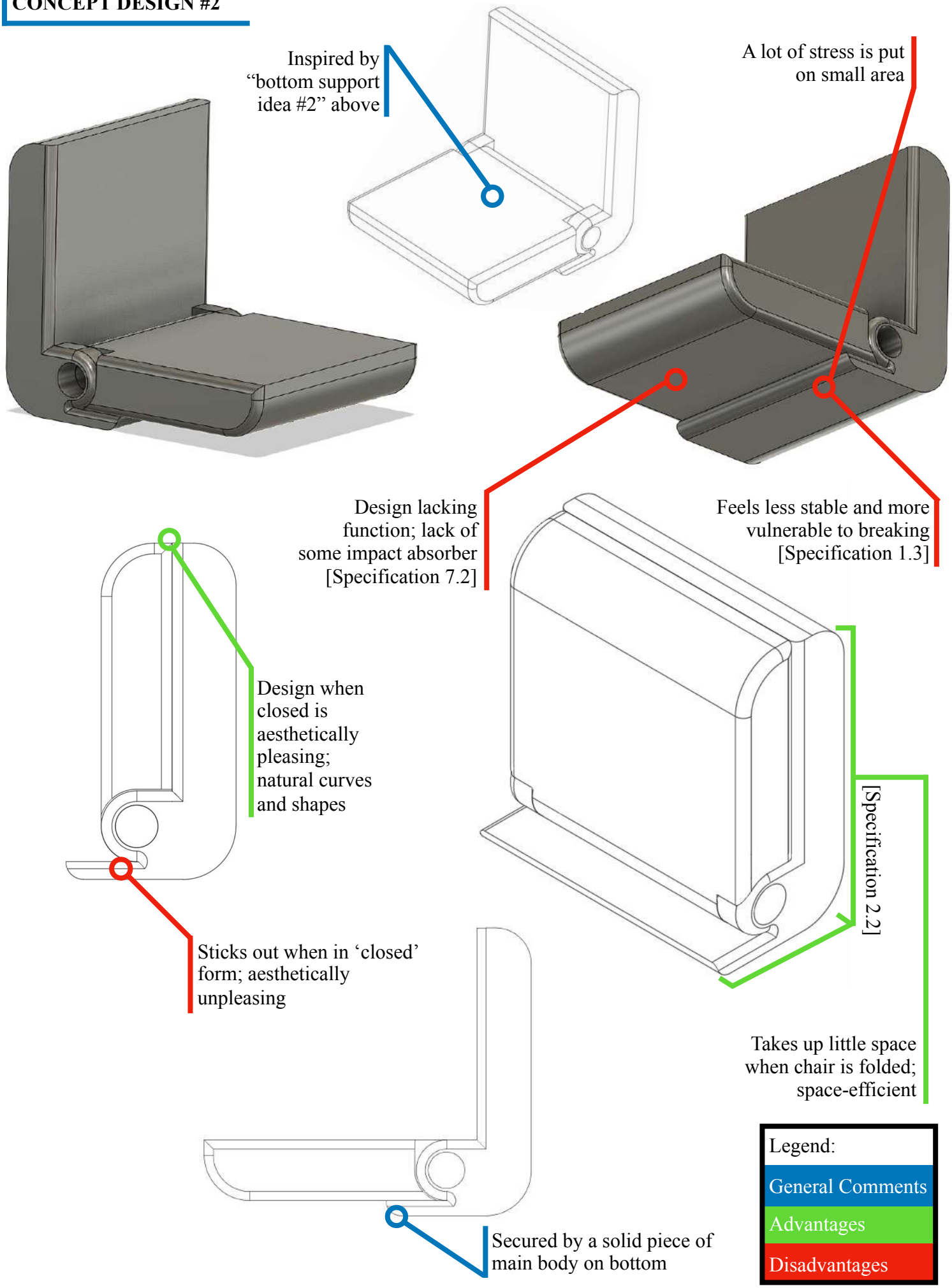


Make sure middle of seat is structurally stable

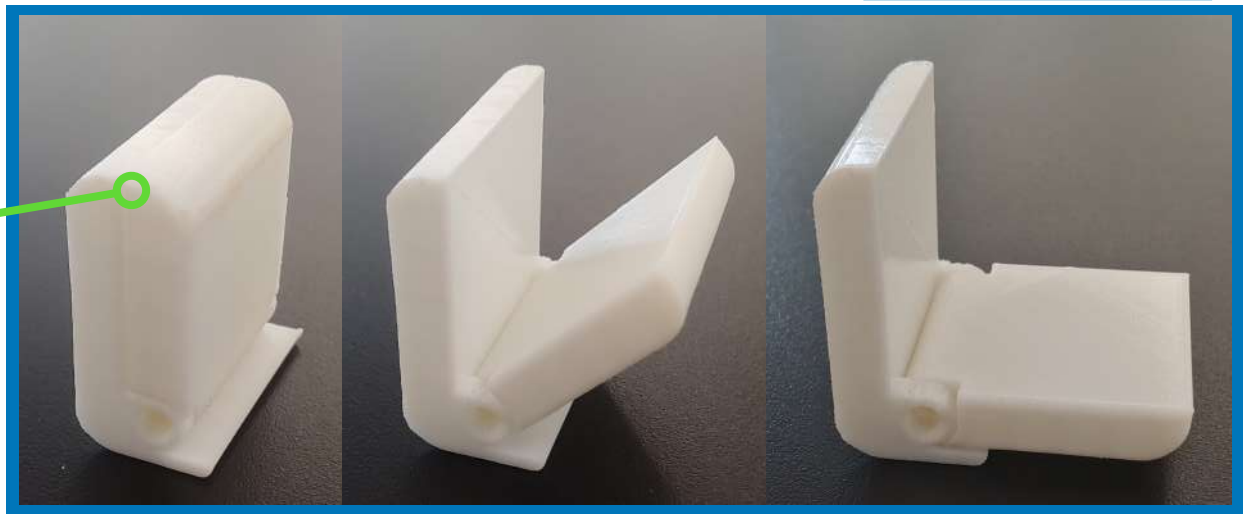
Most stress on the different joints

Criterion B.2: **Development of Ideas**

CONCEPT DESIGN #2

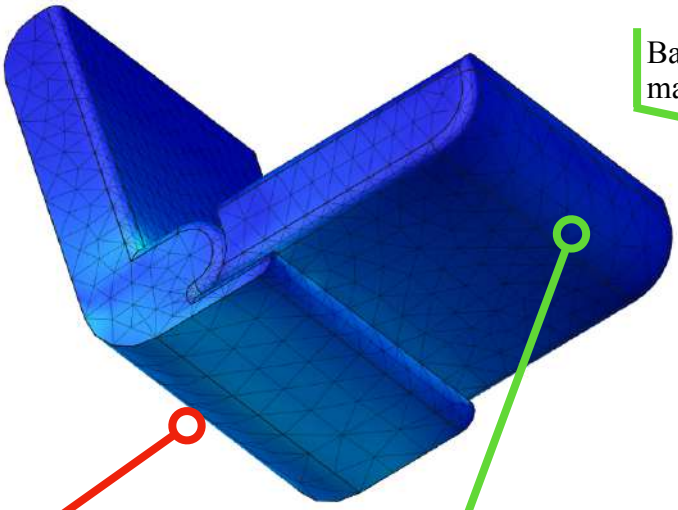


3D Printed Scaled Model

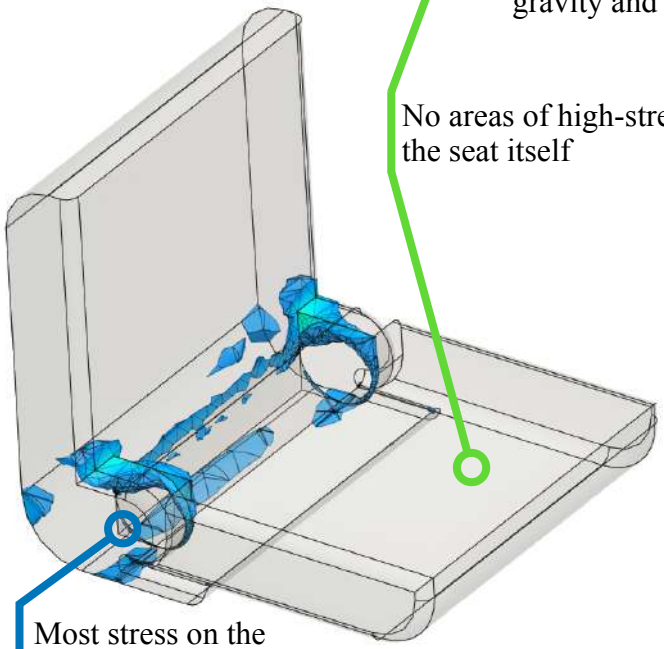


Aesthetically pleasing when closed [Specification 3.1]

Stress FEA



A lot of stress on the lower support

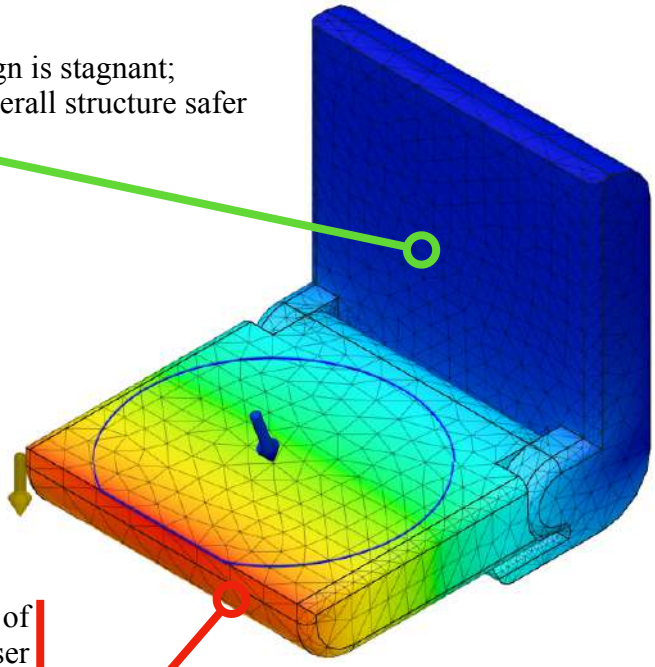


No areas of high-stress on the seat itself

Most stress on the joint parts

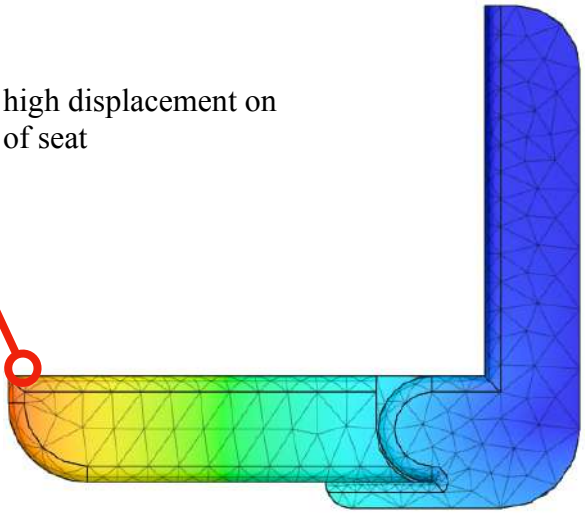
Displacement FEA

Back of design is stagnant; makes the overall structure safer



Due to both force of gravity and weight of user

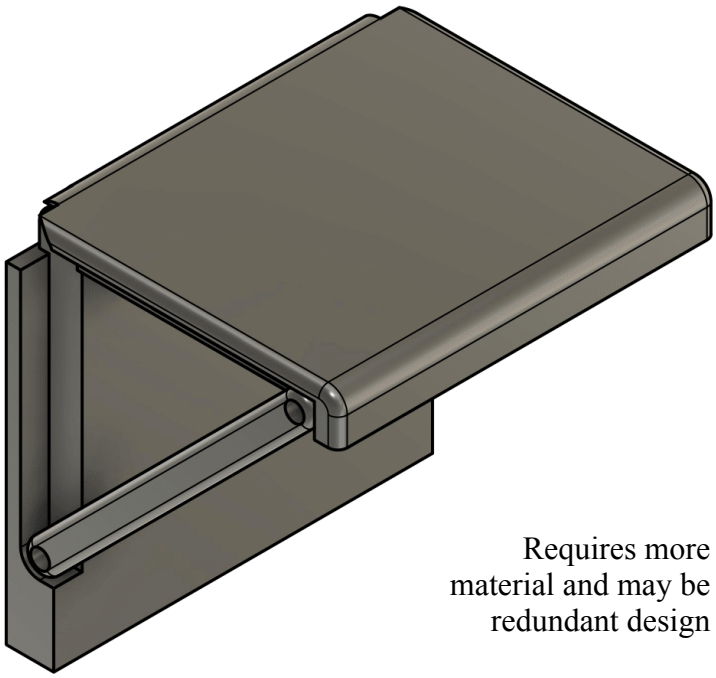
Very high displacement on edge of seat

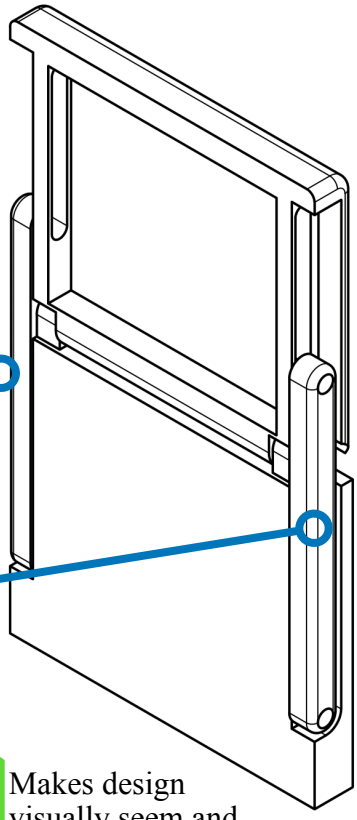


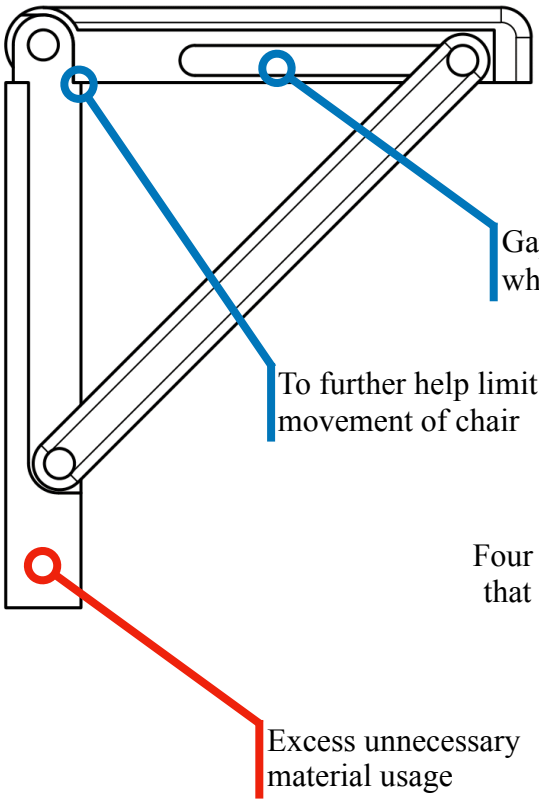
Criterion B.2: **Development of Ideas**

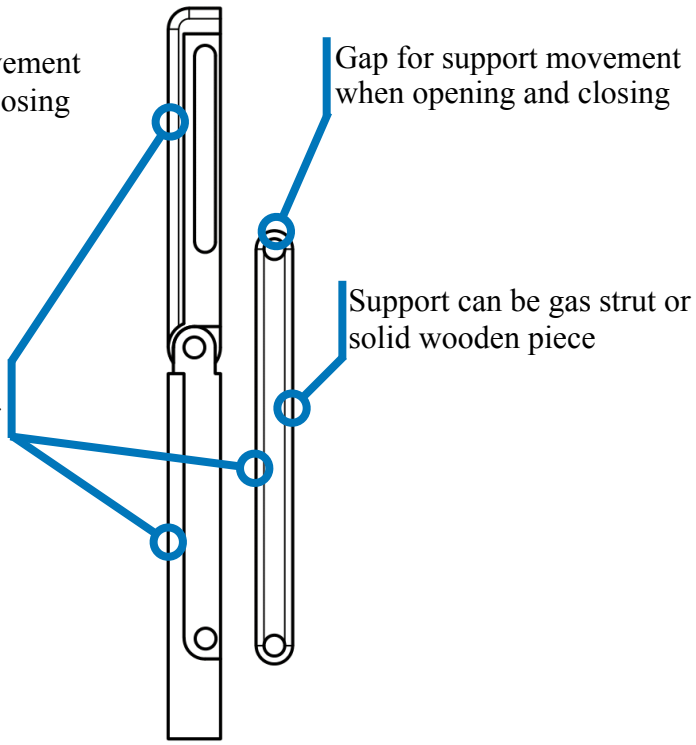
CONCEPT DESIGN #3

Legend:
- General Comments
- Advantages
- Disadvantages

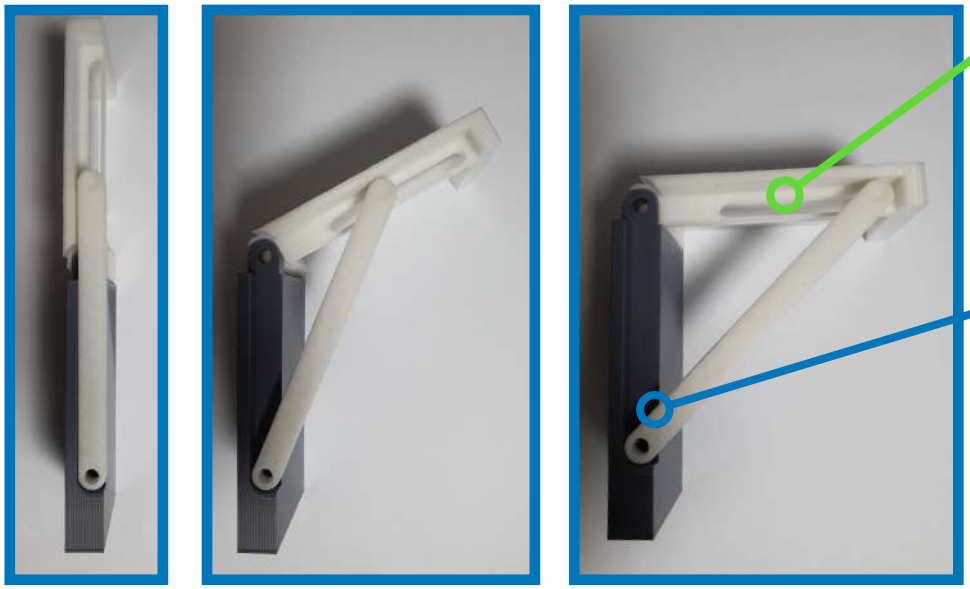








3D Printed Scaled Model

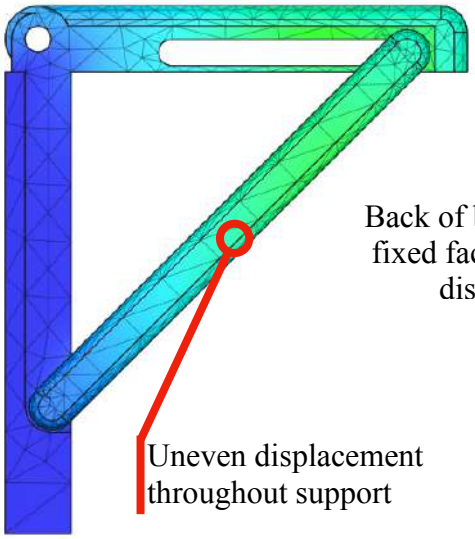


The allows for and limits movement of bottom support

Bottom point fixed in place

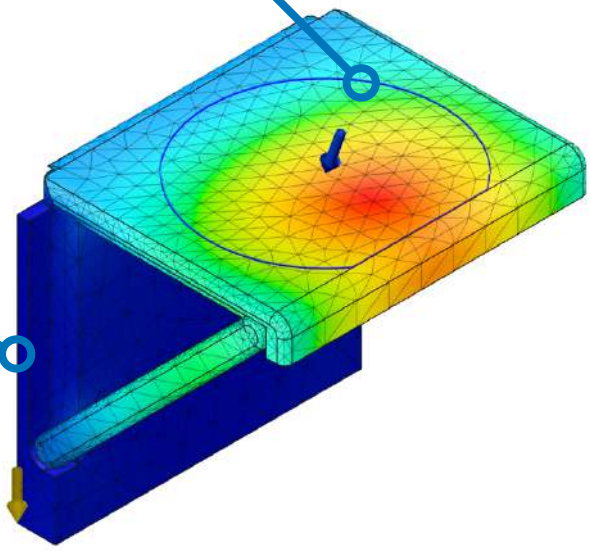
Main seat material should be rigid to minimize displacement

Displacement FEA



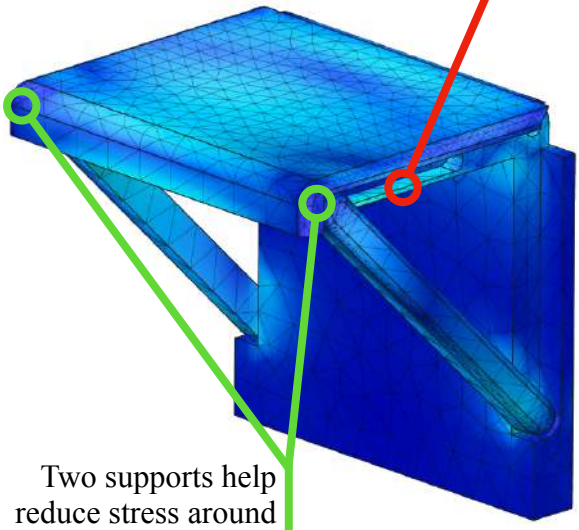
Back of base set as fixed face, thus no displacement

Uneven displacement throughout support

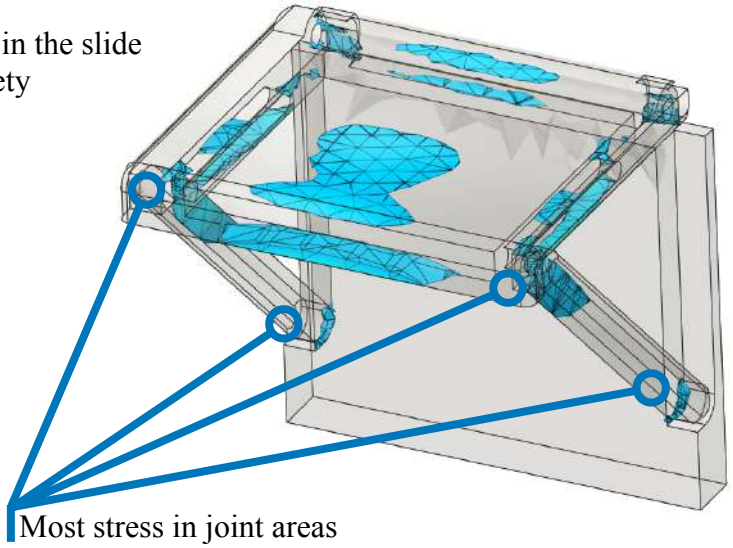


Stress FEA

A lot of stress in the slide area, risks safety



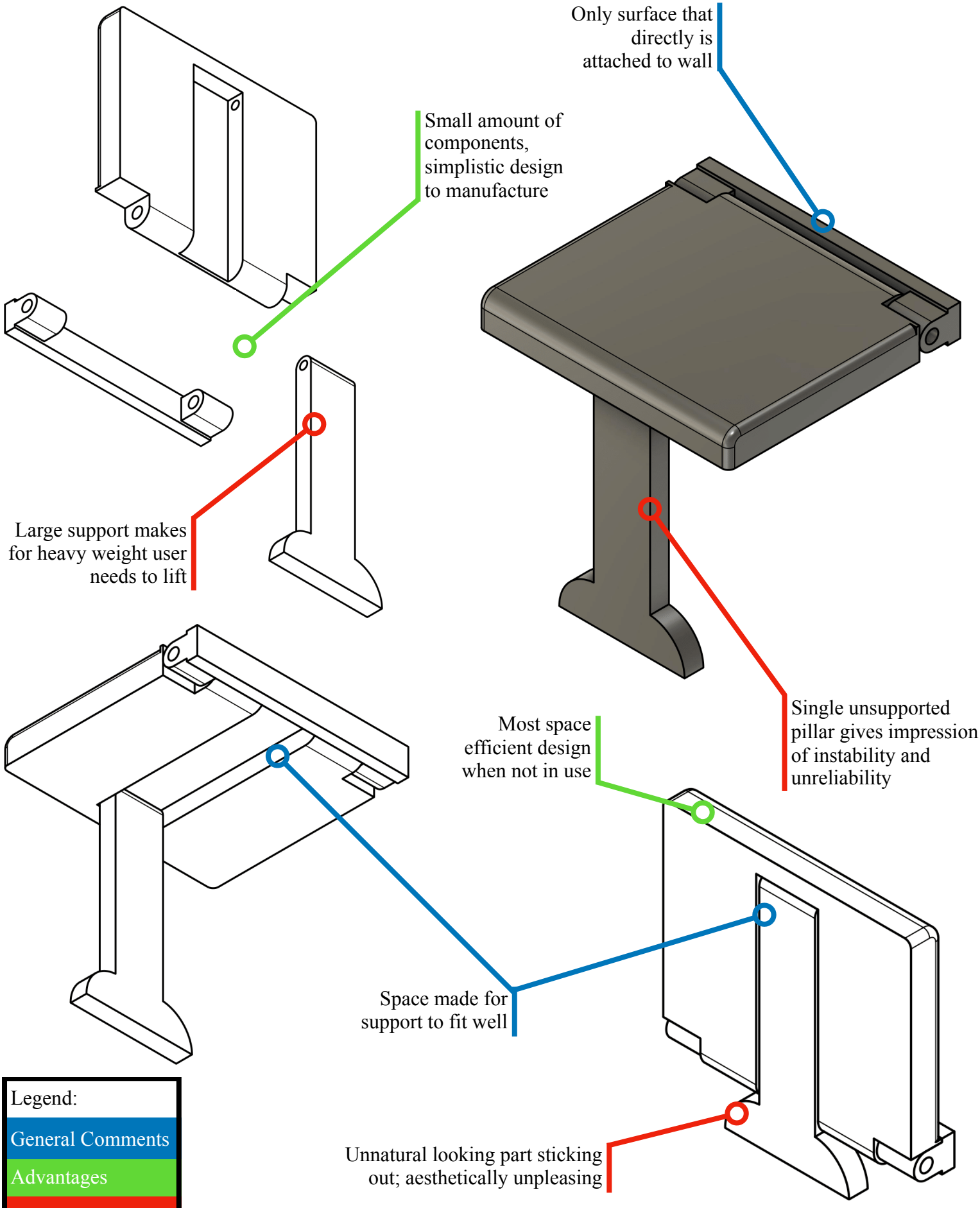
Two supports help reduce stress around the edge of seat



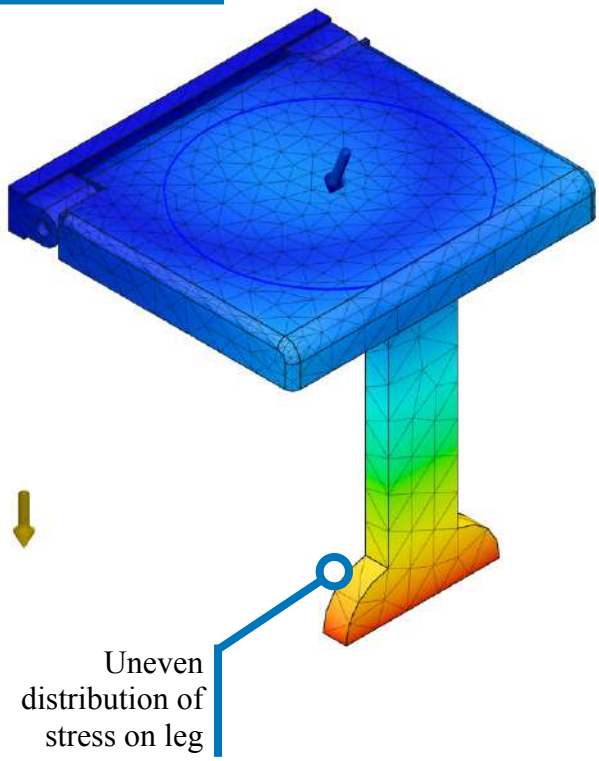
Most stress in joint areas

Criterion B.2: **Development of Ideas**

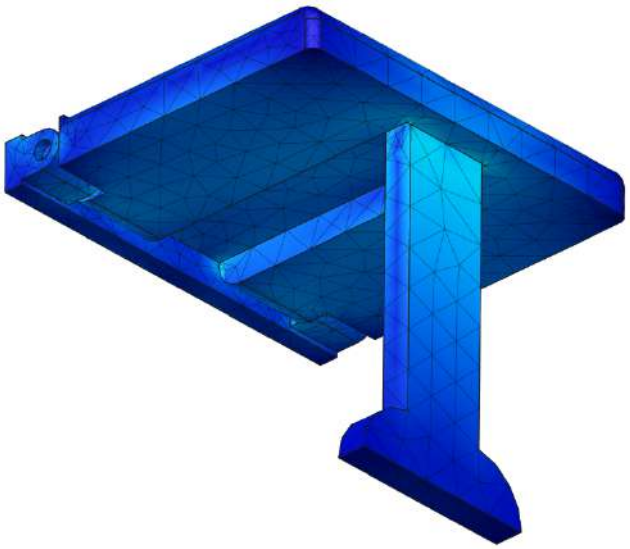
CONCEPT DESIGN #4

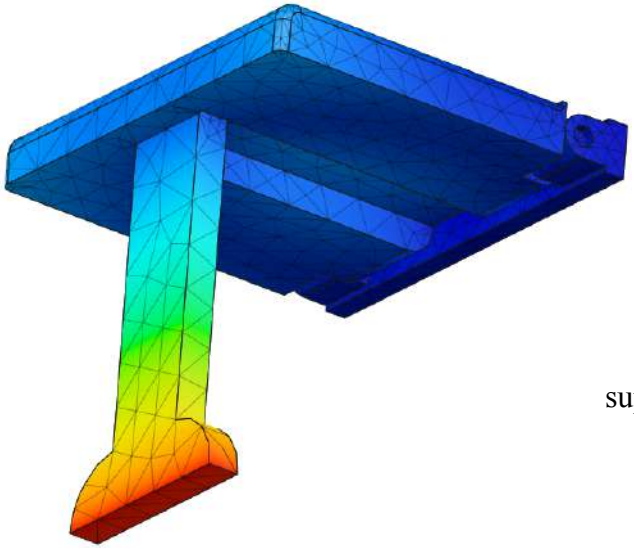


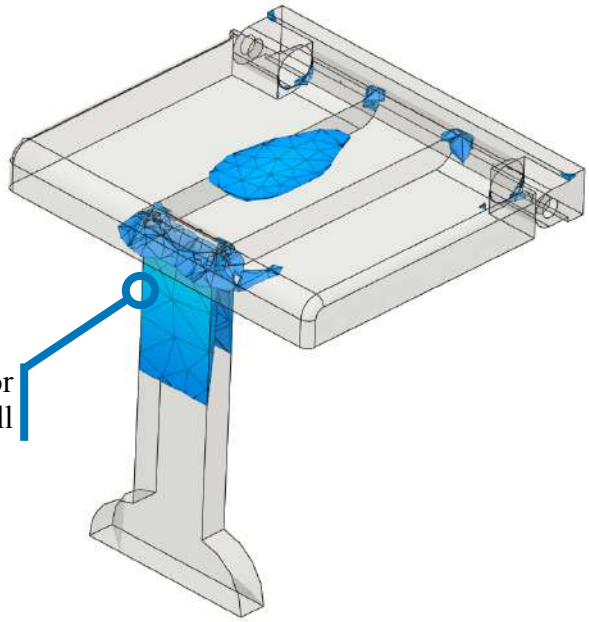
Displacement FEA



Stress FEA

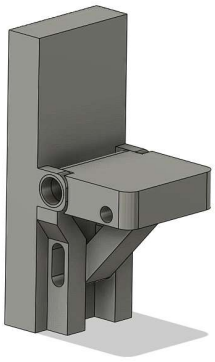
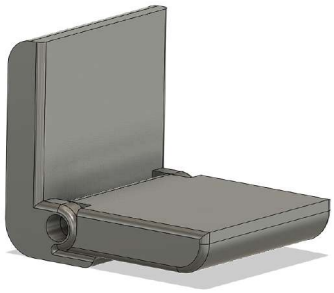
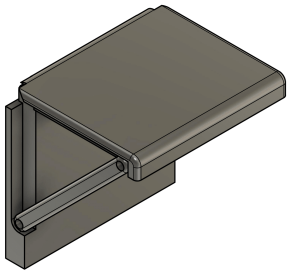
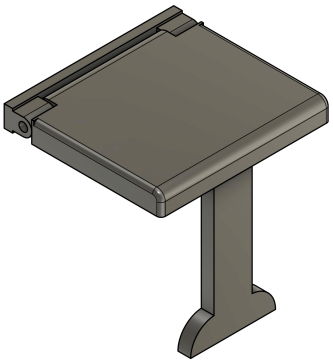






3D Printed Scaled Model

Criterion B.3: **Justification of Detailed Design**

Spec.	Design #1	Design #2	Design #3	Design #4
				
1	5/5	3/5	4/5	3/5
2	2/5	4/5	3/5	5/5
3	3/5	5/5	2/5	3/5
7	5/5	2/5	5/5	2/5
Avg.	3.0/5	2.8/5	2.8/5	2.6/5

WRITTEN JUSTIFICATION

The various scores given above to the different specification for each design was determined through user interviews, expert interviews, FEA analysis, and physical prototyping.

The bottom support of design #1 and #3, where there are leg(s) that are attached to the base of the chair, is a design choice that was met with many positive reactions and one that will be implemented into the final design. It not only provided structural support but also made the users feel psychologically safe. The use of a “dropping” support like the one in design #4 was inconsistent in tis forms change while testing the function with the prototype; therefore, it will not be implemented into the final design.

The idea of using a gas strut as the aforementioned support will be implemented, as it will not only support the opening and closing mechanism of the chair but will also help absorb some of the impact caused when sitting on a chair. Though it will increase manufacturing costs, it was deemed worth it to invest more into the safety and convenience of the users.

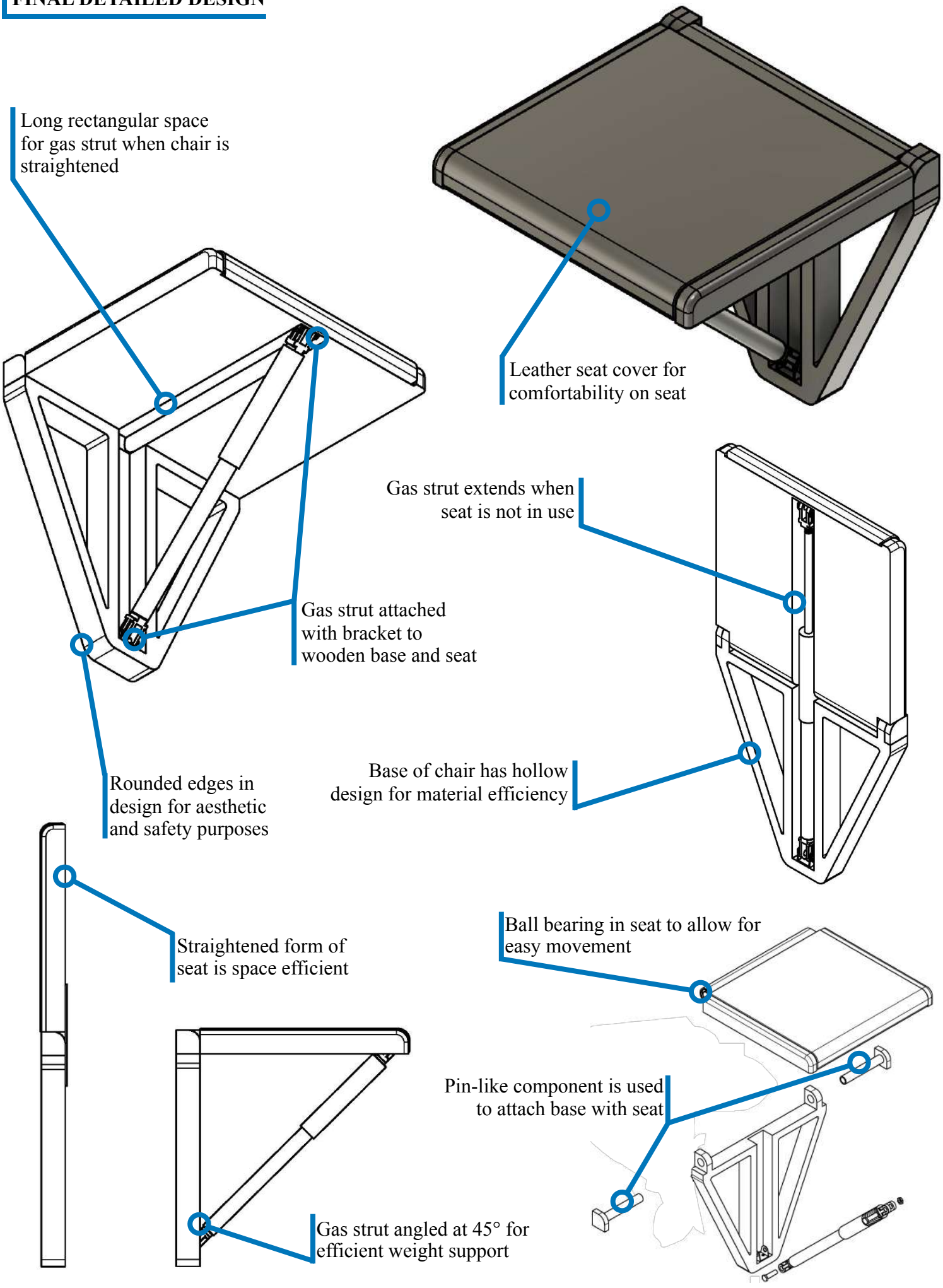
The present of a back section on the chair, like on design #1 and #2, is a design aspect that will not be implemented into the final design. It was determined that it is redundant, as the chair will be against a wall that can act as the back of the chair; additionally, is just an unnecessary use of material.

Regarding the shape of the seat itself, the ‘rounded edge’ design, like the ones present in design #3 and #4, was met with a lot of positive feedback. As the design is based off of many office chairs, chairs designed for people to sit comfortably for a long period of time, it makes sense for this feedback.

In conclusion, the final design will consist of a combination of different aspects from the four designs explored that were met with positive results, whether it’d be from user/expert feedback or from prototype testing.

Criterion B.3: **Justified Detailed Design**

FINAL DETAILED DESIGN



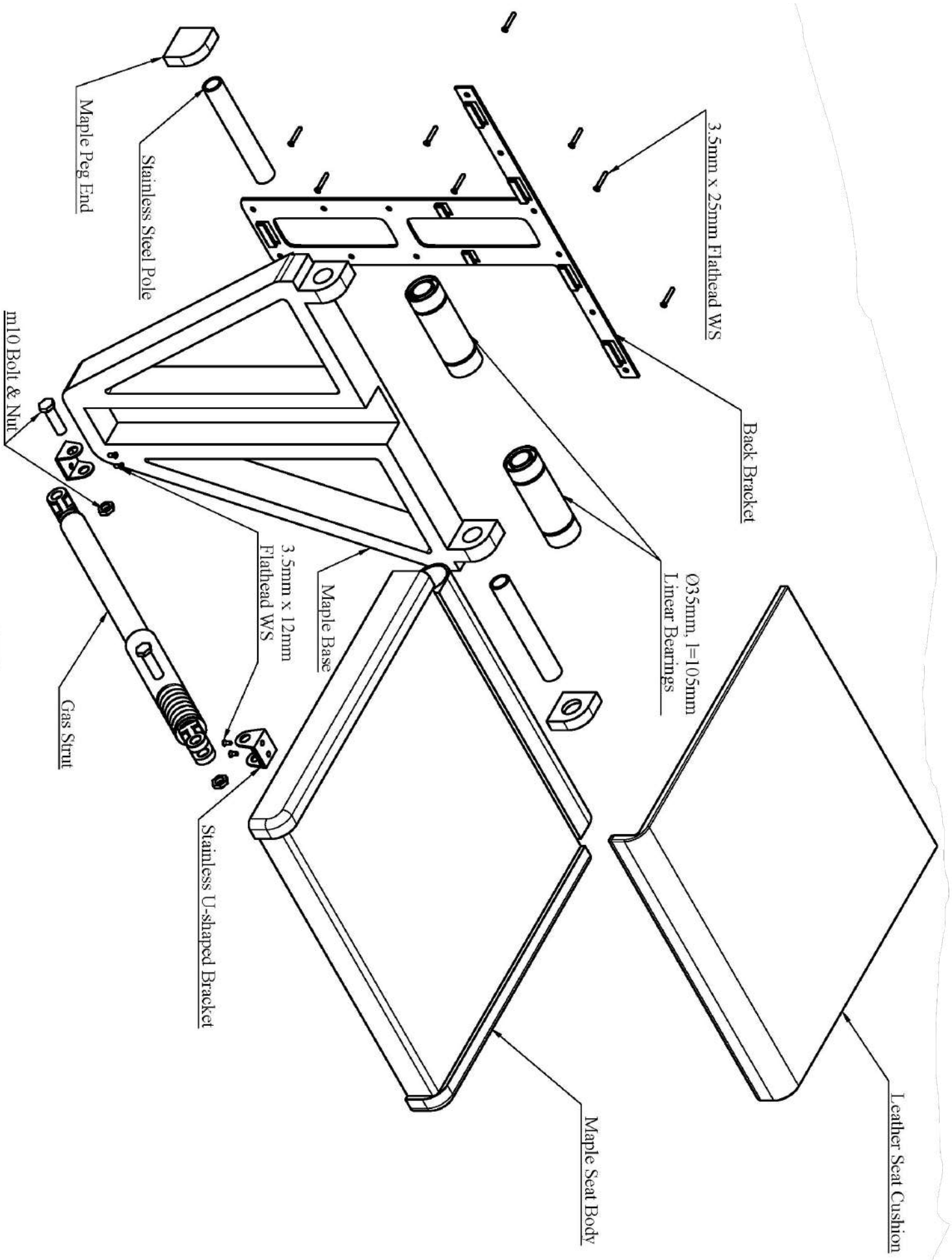
Criterion C.1: **Design Brief**

Comp. #	Component Name	Material / Manufacturing Technique	Justification
1.1	Seat Cushioning	Faux leather, Polyurethane foam 	+ Affordable + Easy to manipulate + Makes hard seat more comfortable − Made of polyurethane, thermoset plastic, therefore difficult to recycle
1.2	Seat Body	CNC milled 40mm Maple Wood Board 	+ Hardwood + Able to use screws as joining technique + Long durability + Easy to clean and repair (dents and/or scratches) + Dense cellular structure allows for great strength + Makes hard seat more comfortable − Complicated manufacturing process
1.3	Linear Bearing	⌀35mm, L =105mm Linear Bearing	+ Allows for easy and smooth up/down movement of chair − Increases cost
2.1	Chair Base	CNC milled 40mm Maple Wood Board	• Similar justification to use of maple wood from *component #1.2* above
3.1	Stainless Steel Pole	⌀20mm Stainless Steel Pole 	+ High tensile strength + Easy fabrication + Recyclable; Environmentally friendly − Costly
3.2	Peg End	CNC milled 20mm Maple Wood Board	• Similar justification to use of maple wood from *component #1.2* above • Thickness less than component #1.2 & #2.1
4.1	Back Bracket	Laser cut t=2.5mm Stainless Steel sheet 	+ Low maintenance + Relatively easy fabrication + High tensile strength; will be effective in − Increases cost
Ex.	Joining components	• 3.5mm x 25mm Flathead WS • 3.5mm x 12mm Flathead WS • M10 Nuts & Bolts	+ Permanent joining technique; designed for disassembly (Environmentally friendly) + High tensile strength; will be effective in holding various part together for a long period of time
Ex.	Steel U-Brackets	Stainless steel U-shaped brackets for nuts & bolts	• To attach the gas strut to the base and seat of the chair, a metal bracket is needed

Criterion C.2: Final Design Renders

Criterion C.2: Final Design Renders

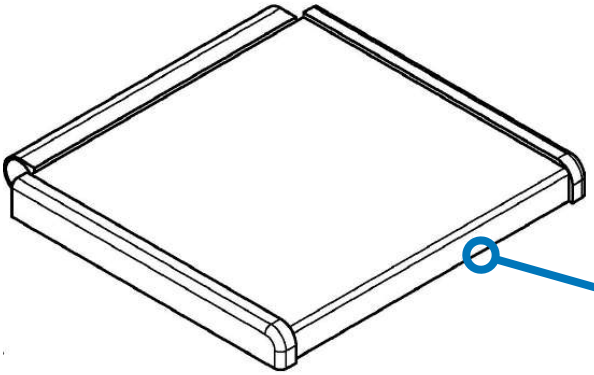
Criterion C.2: Final Design Orthographic Assembly Drawing

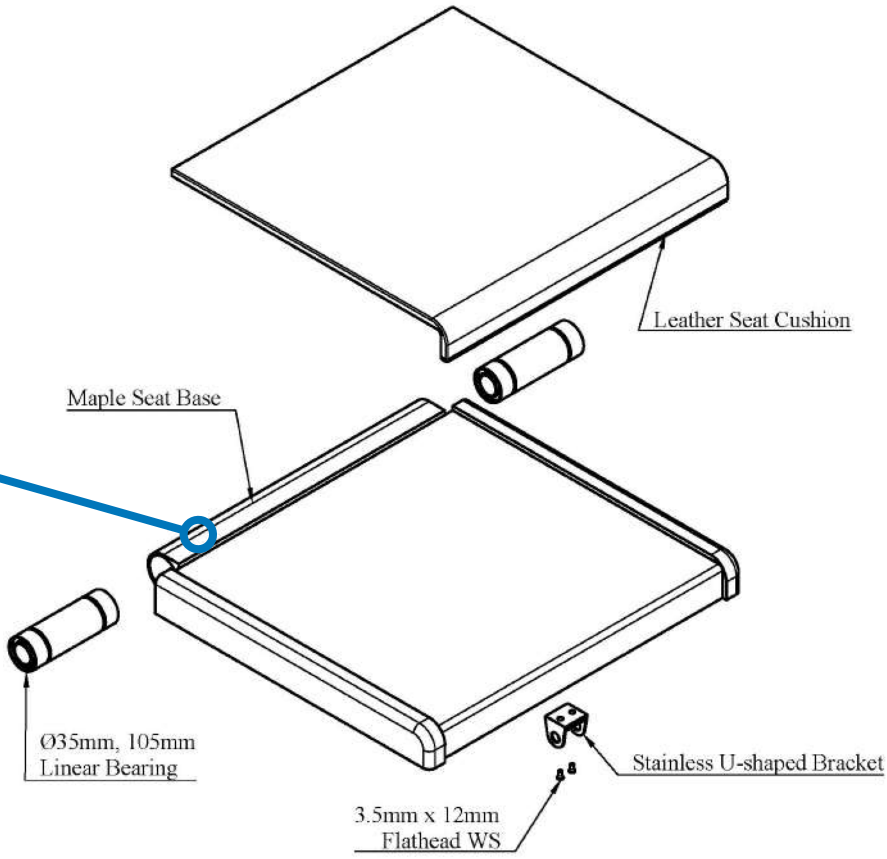


Criterion C.2: Final Design Orthographic Assembly Drawing

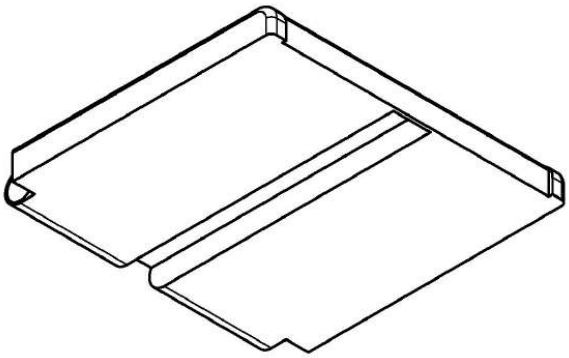
Component #1 - Seat

Top Isometric View

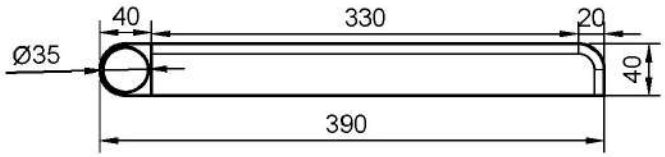




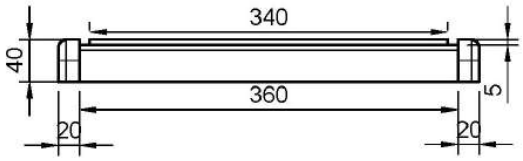
Bottom Isometric View



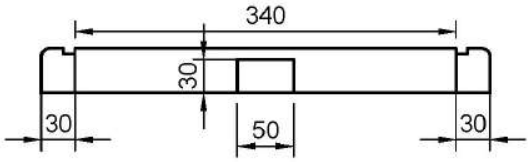
Side View



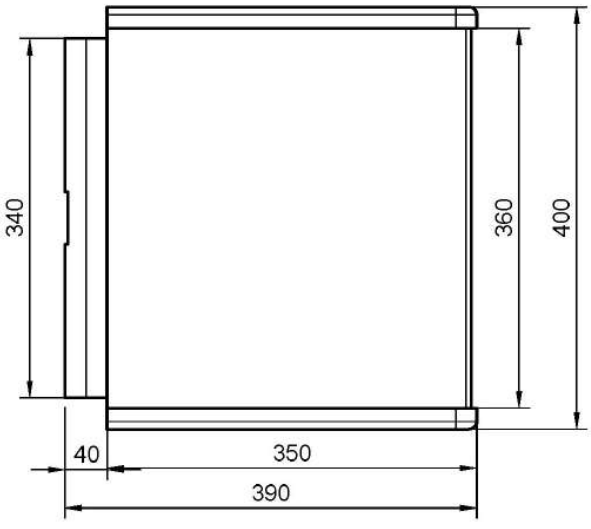
Front View



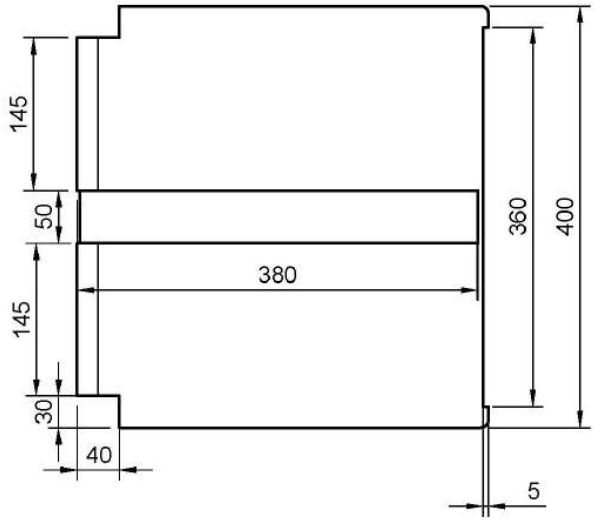
Back View



Top View

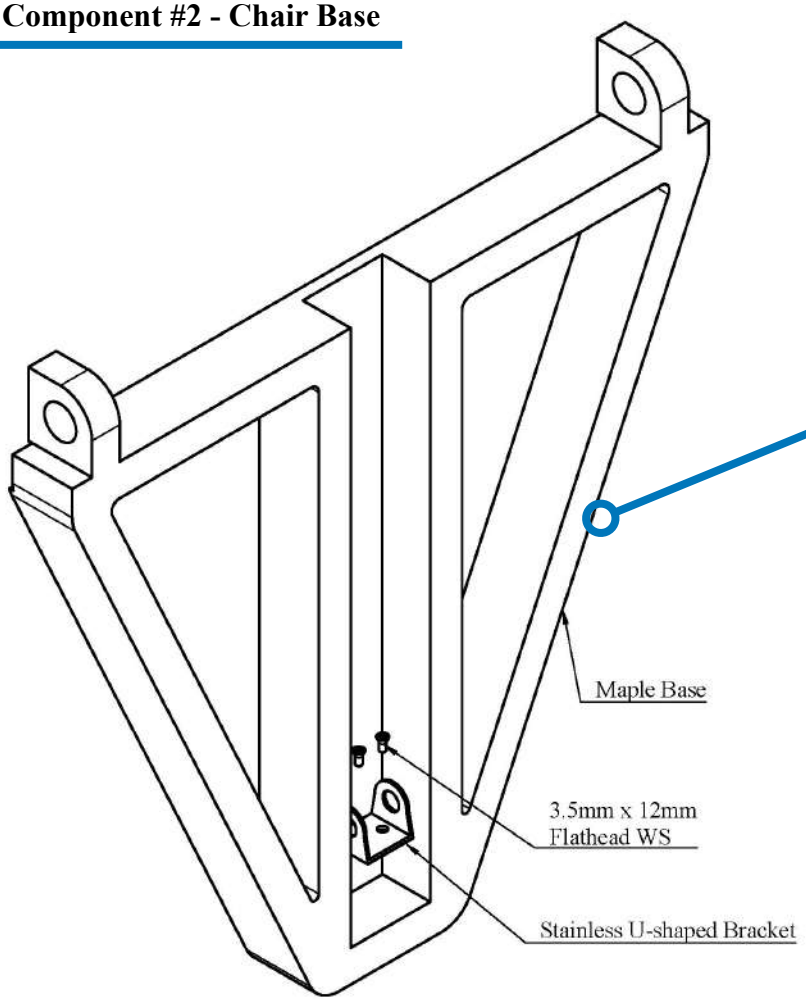


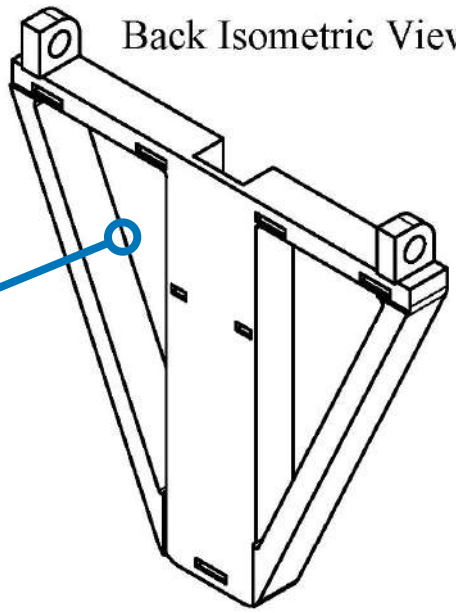
Bottom View

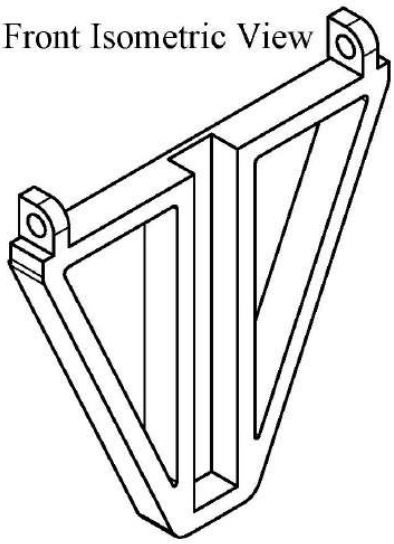


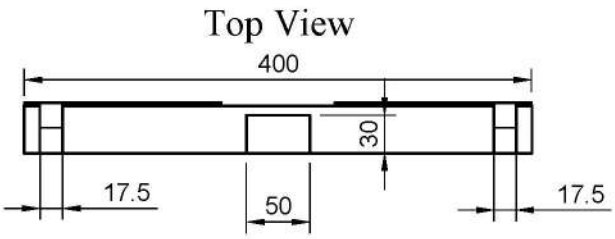
Criterion C.2: Final Design Orthographic Assembly Drawing

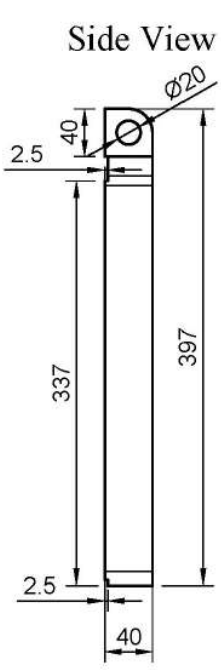
Component #2 - Chair Base

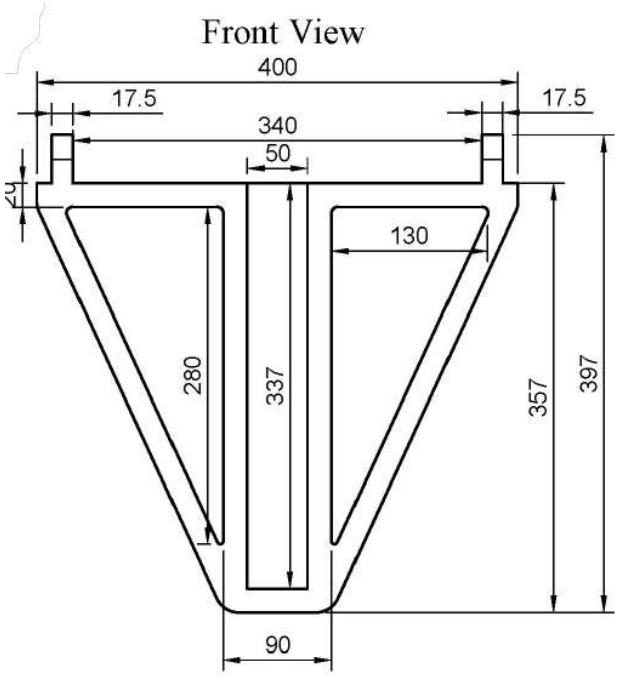


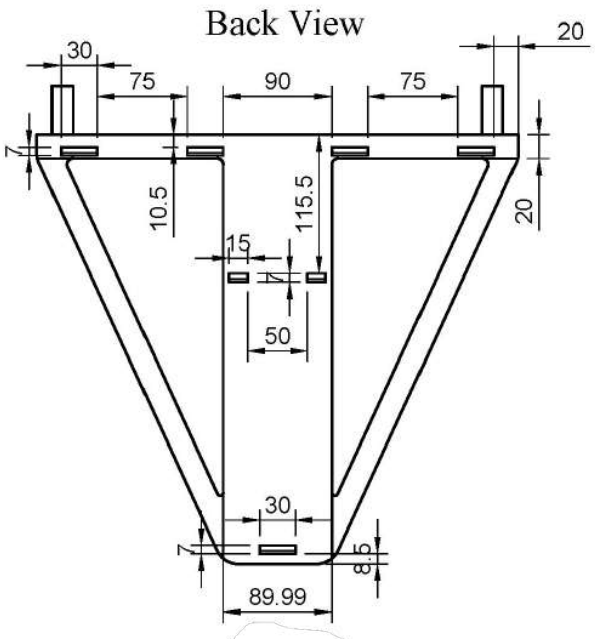






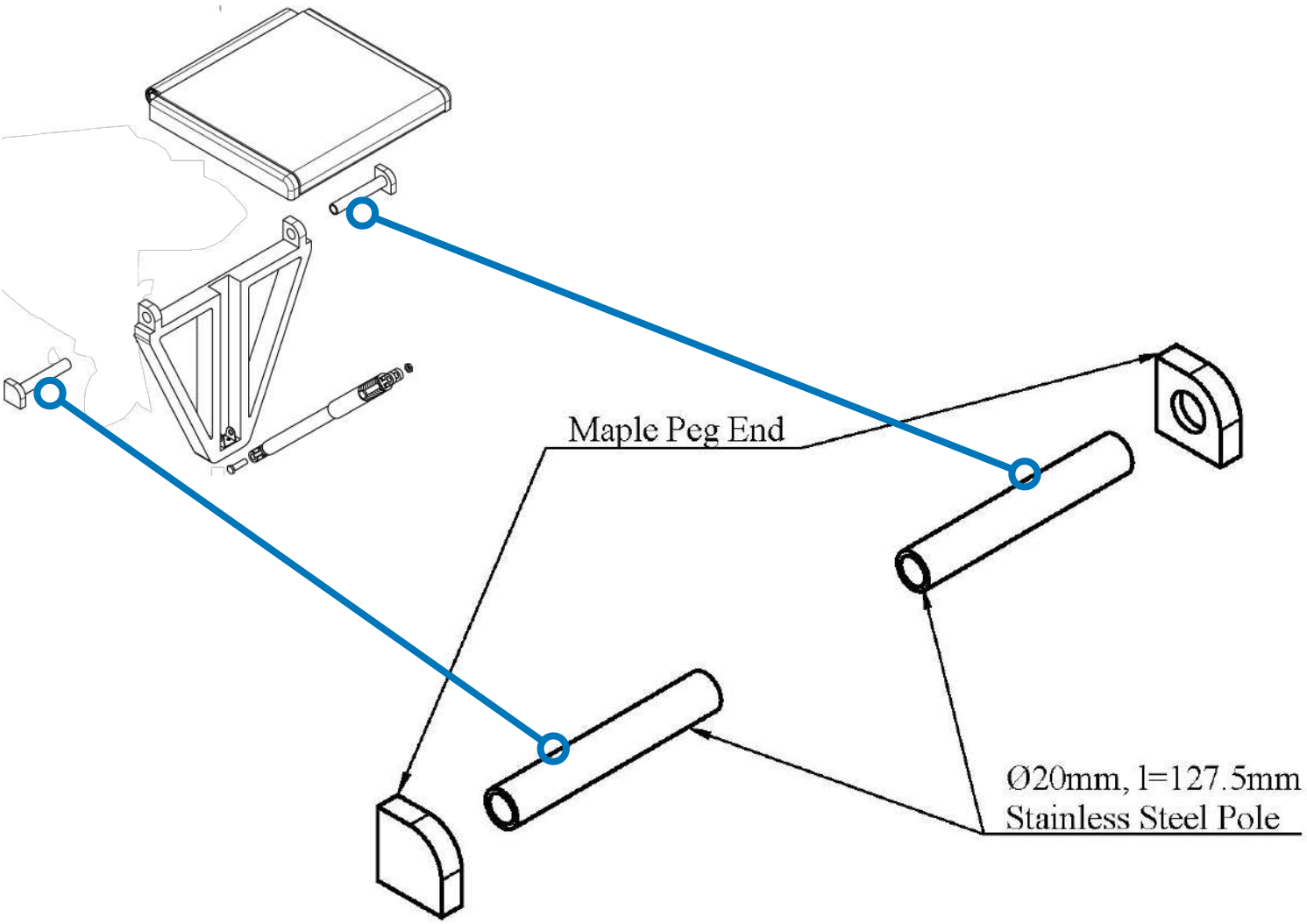




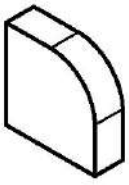


Criterion C.2: Final Design Orthographic Assembly Drawing

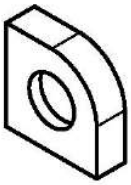
Component #3 - Base Peg



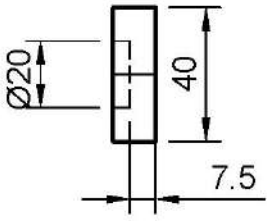
Isometric View



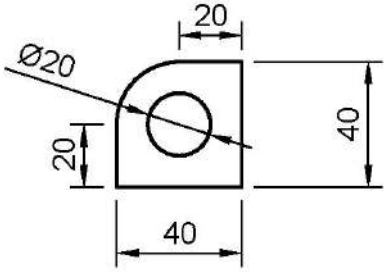
Isometric View



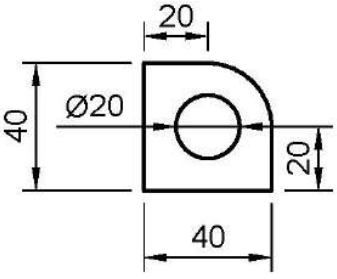
Front View



Side View

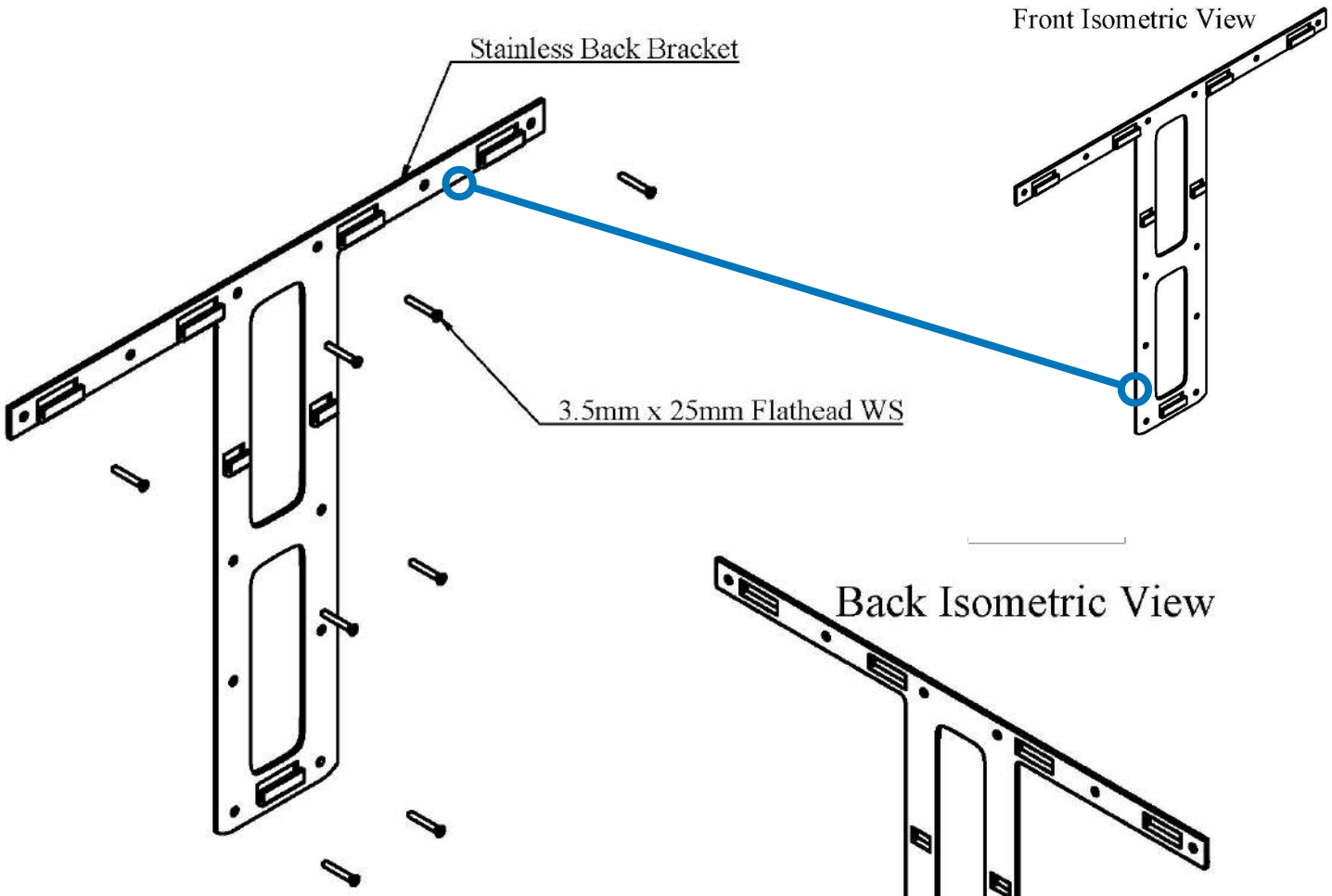


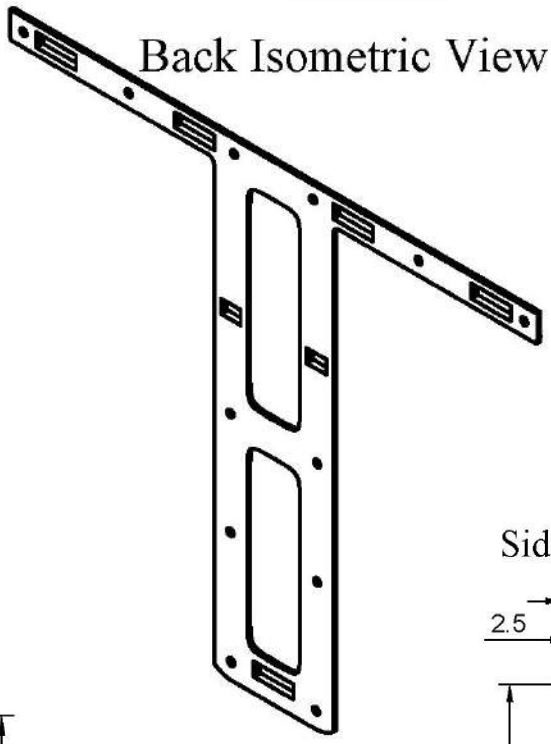
Side View

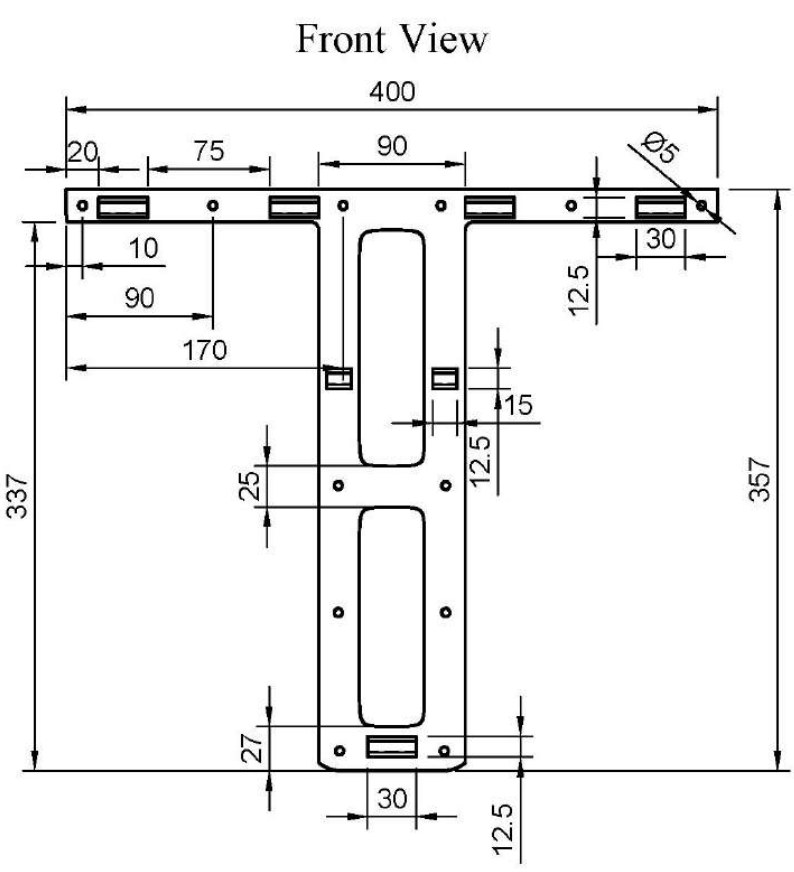


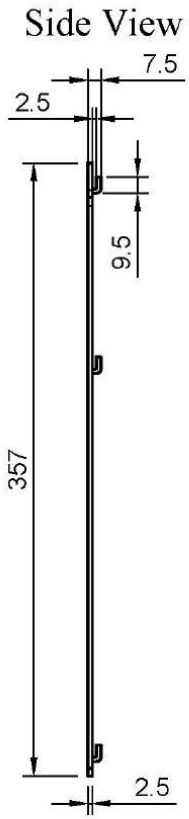
Criterion C.2: Final Design Orthographic Assembly Drawing

Component #4 - Back Bracket









Criterion C.3: Manufacturing Plan

Step	Process	Equipment	Scheduling	Quality Control	Risk Assessment
1.1	Saw rough form of maple seat body	• Jigsaw • Drill • Pencil • Ruler	≈ 1.5 Hrs	• Check measurements before & after cutting • Ensure cut angles are correct	• Safety glasses • Hearing protection • Dust mask • No jewelry/loose clothing
1.2	Sand rough edges of seat body	• Orbital Sander • Various grit of sandpaper	≈ 30 Mins	• Check smoothness with hand • Double check all relevant corners/edges	• Safety glasses • No jewelry/loose clothing/gloves
1.3	Add leather seat cushion	• Epoxy glue	≈ 10 Mins	• After drying, tug on cushion to ensure it stays on	• Use in well ventilated area
1.4	Add linear bearings to seat body	• Mallet	≈ 10 Mins	• Shake the seat to check that bearings are securely fit	• Safety glasses • Beware of fingers when hitting
1.3	Screw on the U-shaped bracket onto the seat body	• Drill	≈ 5 Mins	• Slightly pull on the bracket to ensure it's securely screwed	• Safety glasses • Be in ventilated area • Keep cords clear
2.1	Saw rough form of maple chair base	• Jigsaw • Drill • Pencil • Ruler	≈ 2 Hrs	• Check measurements before & after cutting • Ensure cut angles are correct	• Safety glasses • Hearing protection • Dust mask • No jewelry/loose clothing
2.2	Sand rough edges of chair base	• Orbital Sander • Various grit of sandpaper	≈ 1 Hr	• Check smoothness with hand • Double check all relevant corners/edges	• Safety glasses • No jewelry/loose clothing/gloves
2.3	Screw on the U-shaped bracket onto the chair base	• Drill	≈ 5 Mins	• Slightly pull on the bracket to ensure it's securely screwed	• Safety glasses • Be in ventilated area • Keep cords clear
3.1	Saw the maple peg ends	• Jigsaw • Drill • Pencil • Ruler	≈ 20 Mins	• Check measurements before & after cutting • Ensure cut angles are correct	• Safety glasses • Hearing protection • Dust mask • No jewelry/loose clothing
3.2	Sand rough edges of peg ends	• Orbital Sander • Various grit of sandpaper	≈ 10 Mins	• Check smoothness with hand • Double check all relevant corners/edges	• Safety glasses • No jewelry/loose clothing/gloves

Criterion C.3: Manufacturing Plan

Step	Process	Equipment	Scheduling	Quality Control	Risk Assessment
3.3	Saw appropriate length for the stainless steel pole pegs	• Hacksaw • Bench vise	≈ 10 Mins	• Check if angles of edges are appropriate • Double check length	• Safety glasses • Use appropriate blades • Effectively use vise
4.1	Laser cut metal sheet	• Metal laser cutter • Computer (with gcode program)	≈ 15 Mins	• Double check if measurements are correct after cut	• Never leave machine unattended • Keep area free from flammable objects
5.1	Align seat body and chair base, connect with stainless pole	• Mallet • Vise	≈ 20 Mins	• Move seat up and down to ensure strong, secure connection	• Enough support to hold heavy/large components • Beware of fingers
5.2	Fit in peg ends with mallet	• Mallet • Vise	≈ 10 Mins	• Check for any instability by attempting to move peg end	• Enough support to hold heavy/large components • Beware of fingers
5.3	Attach gas strut	• Wrench	≈ 15 Mins	• Double check if measurements are correct after cut	• Beware of fingers • Check gas strut is in appropriate state

For Installation of Chair

Step	Process	Equipment	Scheduling	Quality Control	Risk Assessment
6.1	Secure back bracket onto wall using appropriate screws	• Drill	≈ 20 Mins	• Check every point screw to ensure the back bracket's security	• Safety glasses • Be in ventilated area • Keep cords clear
6.2	Secure chair onto the wall-mounted back bracket	• None	≈ 5 Mins	• Attempt to move chair to identify any instability	• Enough support to hold heavy/large components • Beware of feet