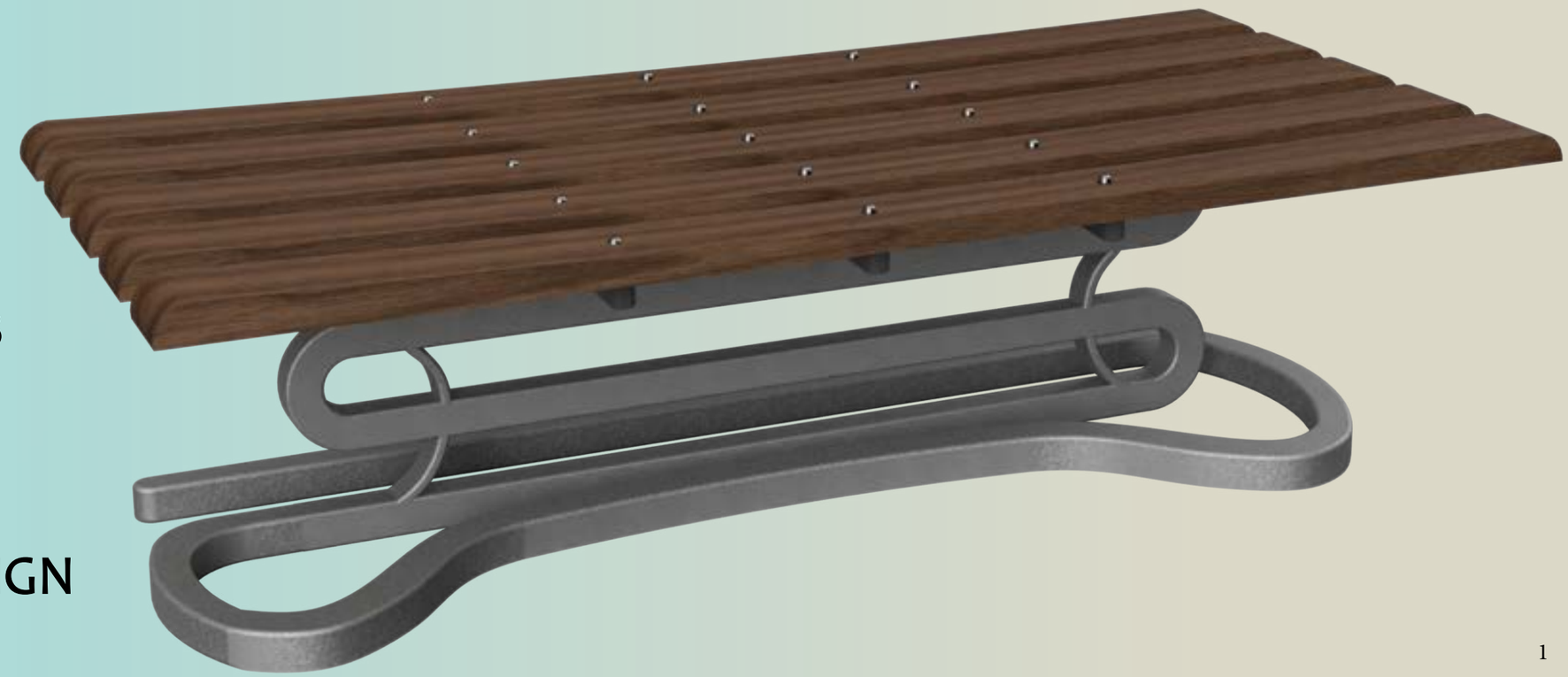
THE SYDNEY SIDERS BENCH

LIAM GILBERT

S00312701

ASSESSMENT TASK 3

FURNITURE CHAIR DESIGN



CONTENTS PAGE

The Design Brief:

Creating furniture that has the ability to be innovative, creative, and unique with a specified setting. This includes creating a piece of furniture that can possibly enhance a setting and environment, or creating a bespoke piece of furniture that relates to a users individual needs.
For this design project, creating a seatable piece of furniture such as a chair will be explored to identify how it can redesigned and suited for additional and other needs.

The Need:

21st century chair design has rapidly advanced our prior perspective on what a chair can achieve, as designers and manufacturers are more readily able to explore new materials such as thermosetting polypropylenes for mass-manufacturing, or alloyed metals for variations in materiality within a design (Foderaro, 2013).

For my design, I intend to fulfill the need of creating a chair that feels comfortable, looks appealing, and is a worthwhile product able to perpetually last.

I intend to find unique shapes and variations that relate to a theme, giving personality to the design, opposed to a mass-manufactured chair that solely serves functional purposes.

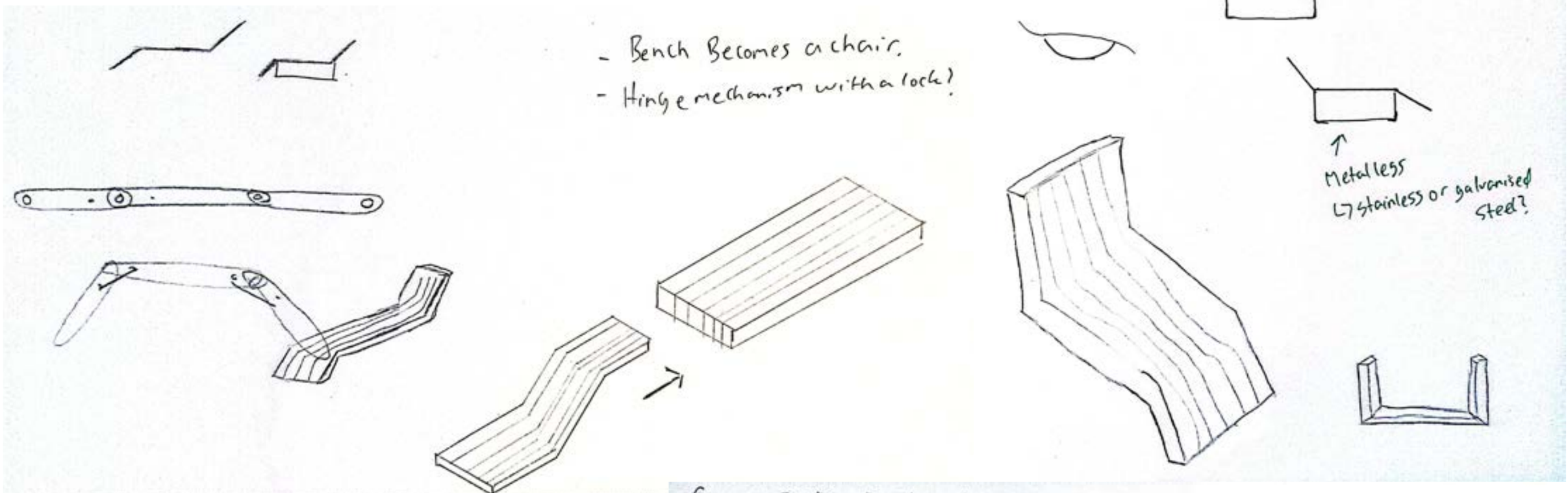
The Aim:

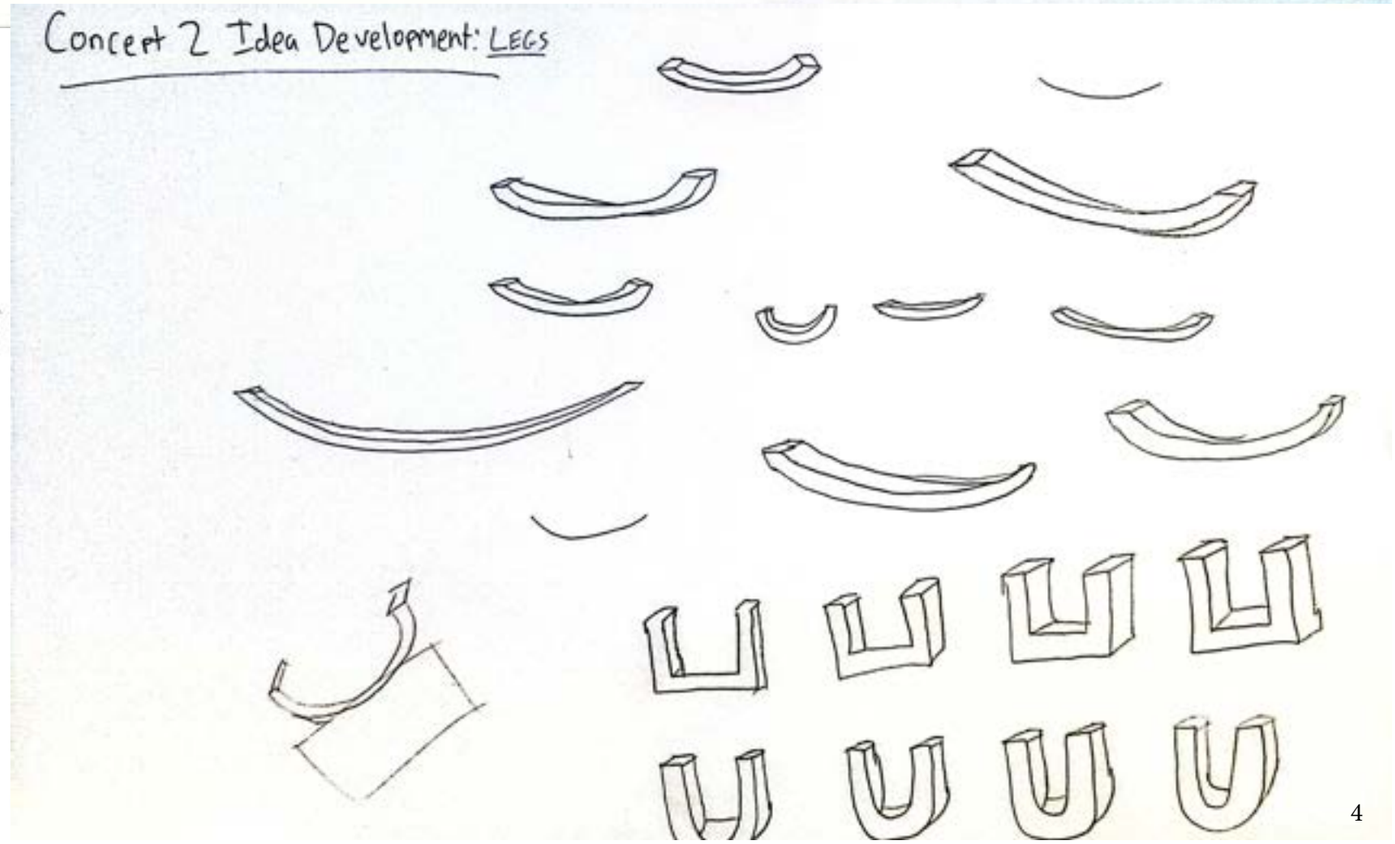
The aim is to design a seatable piece of furniture such as a chair, in an attempt to innovate and create a new design element to how we perceive modern 21st century furniture.

Through the use of sketches, CAD drawings, 3D modelling, and sample joinery tests, I will select and experiment the most appropriate design choices to see which options can fulfill the needs of the design.

I will also seek public input and undergo a series of iterations until I have a greater understanding of what is to be achieved.

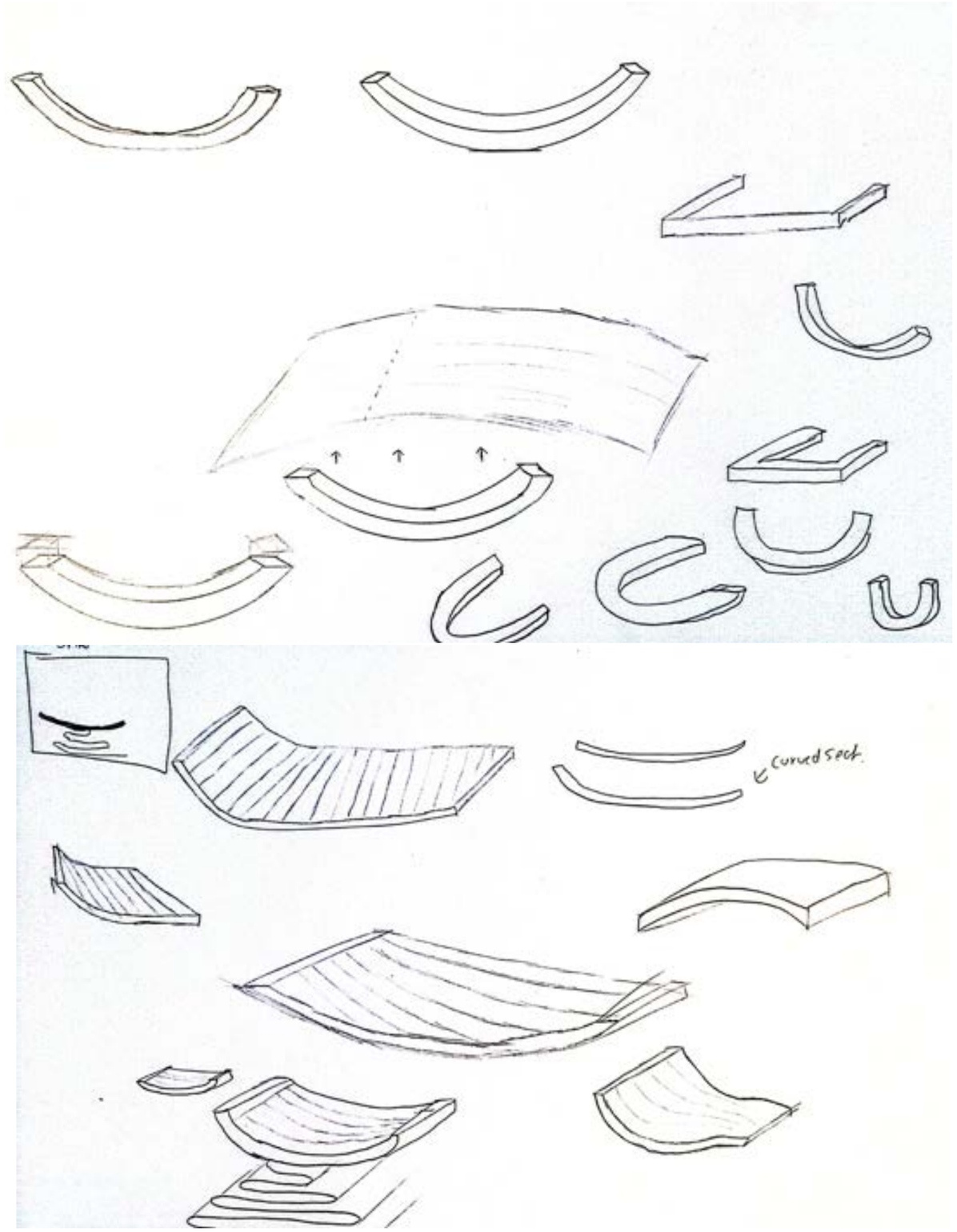
Initial Concept Sketches and Ideas:

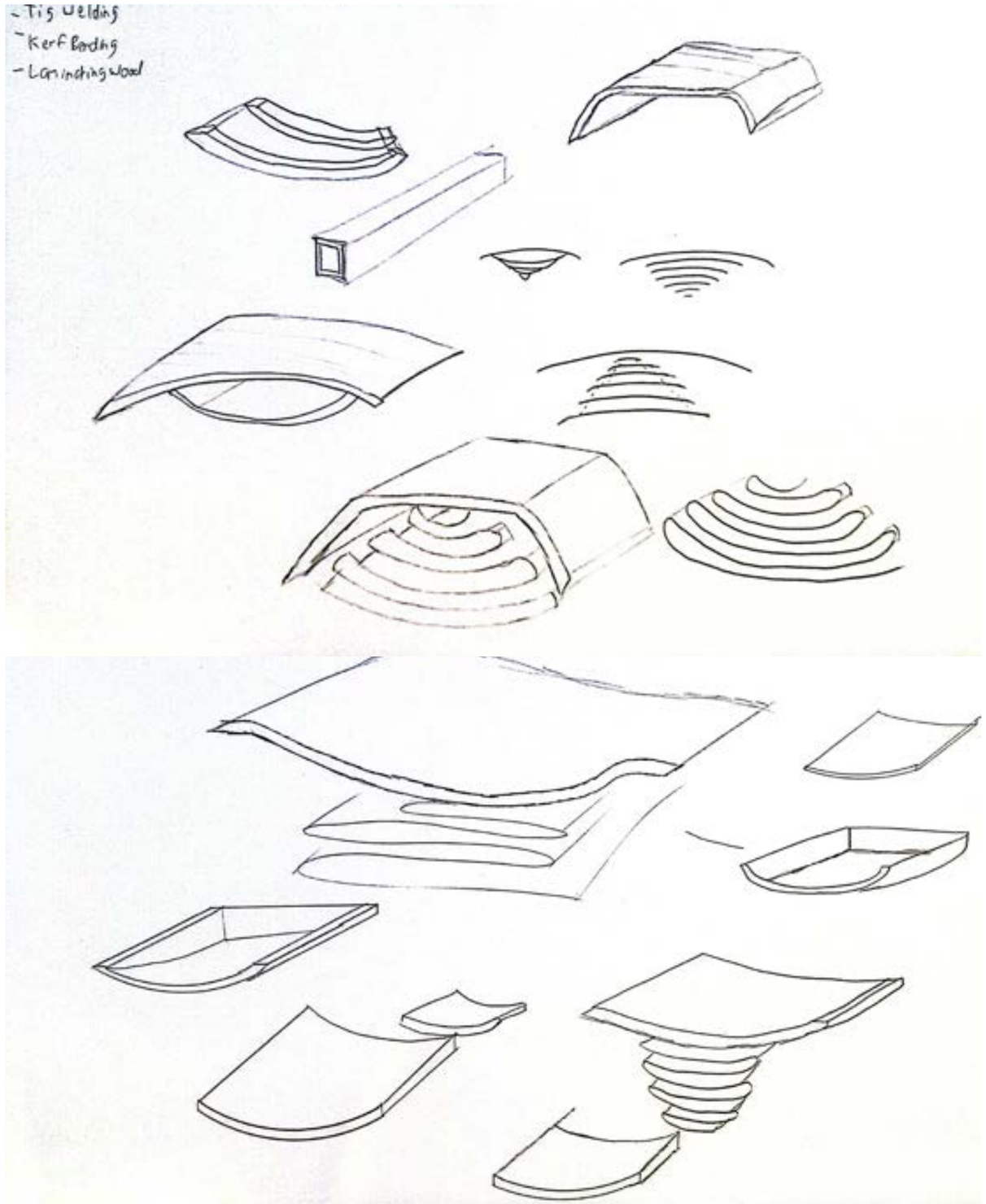




During this stage of the design process, I formulated a series of sketches and ideas to help wrap my head around what I thought I needed to design.
Most of the designs shown here, attempt to explore the shape of the seat, while also understanding what it may potentially appear like.

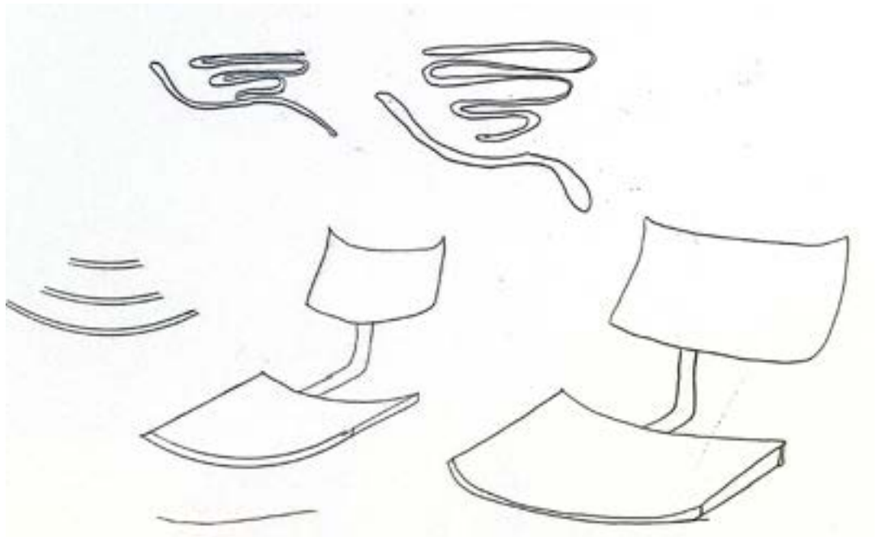
Continued Concept Sketches and Ideas:

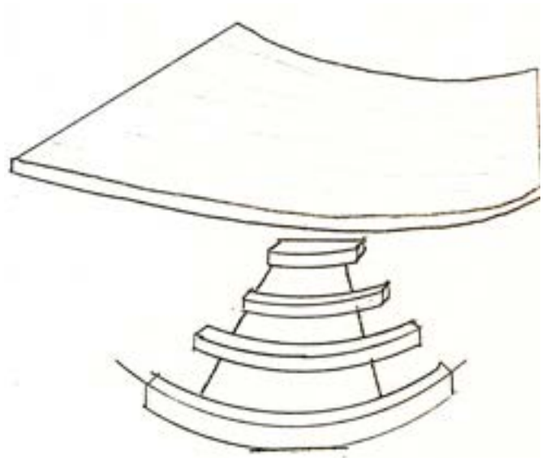


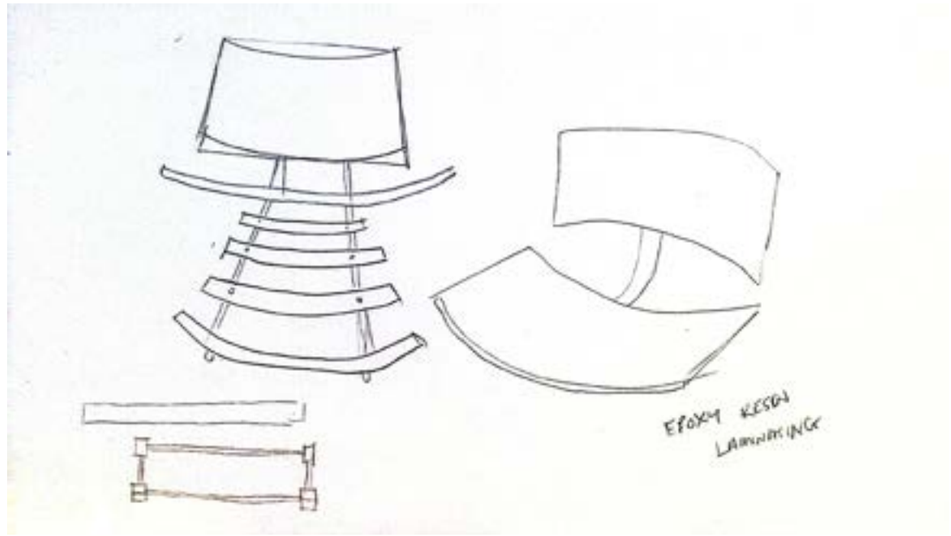


Within this stage of drawings, i attempted to progress my ideas by exploring curves, symmetrical shapes, and visual appeal to the project. I was still formulating ideas at this point, however, they were becoming more actualised via sketching.

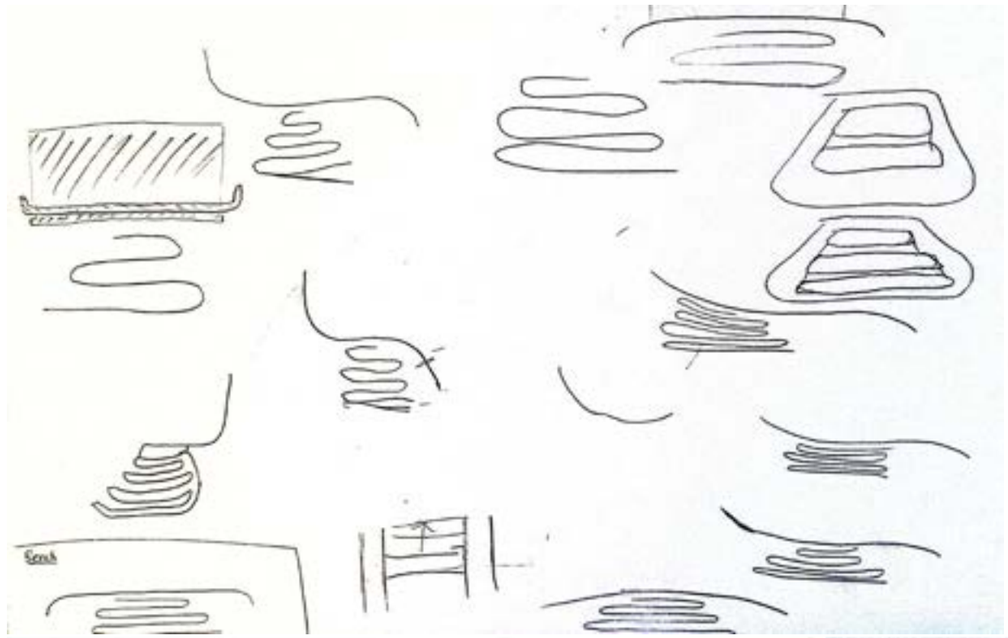
Continued Concept Sketches and Ideas:

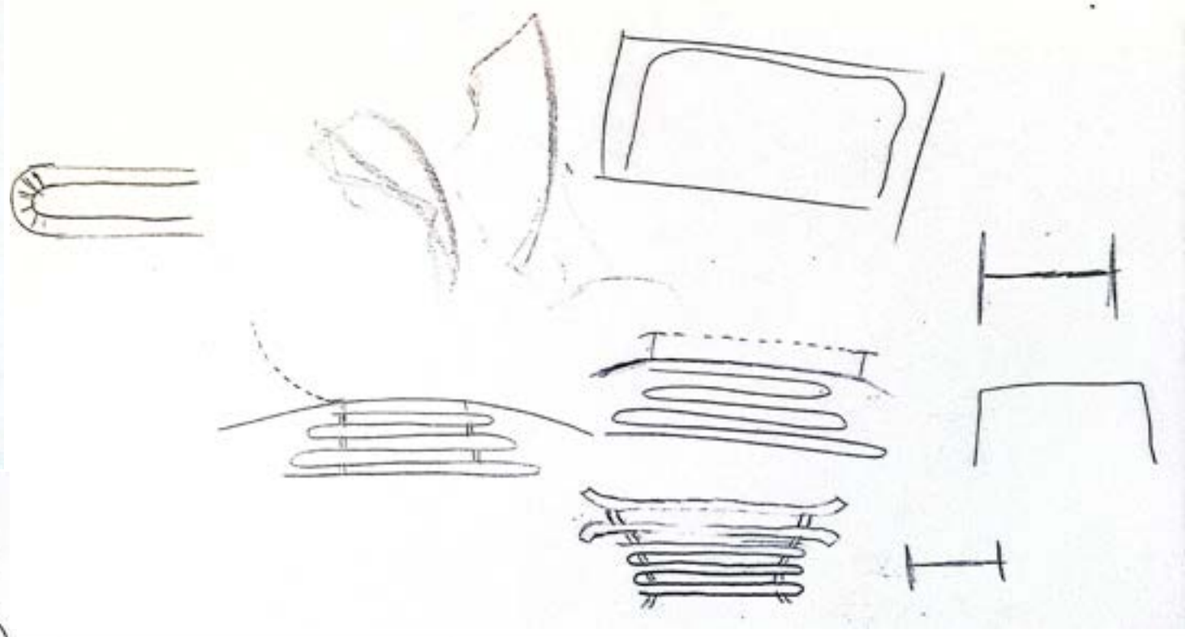


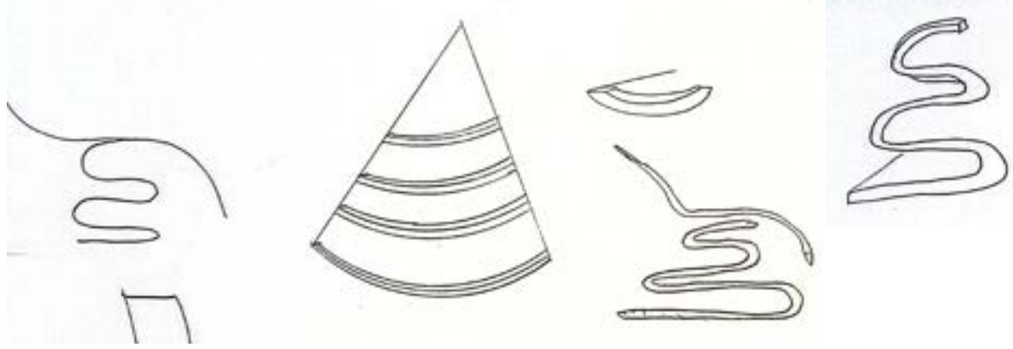




The designs deatured above that depict a chair, was one of the final iterations I had from my concept designs. I believed it looked nice, was practical, and could have the opportunity for mass production, however, nothing visually stood out for me, and I wanted my design to be unique.

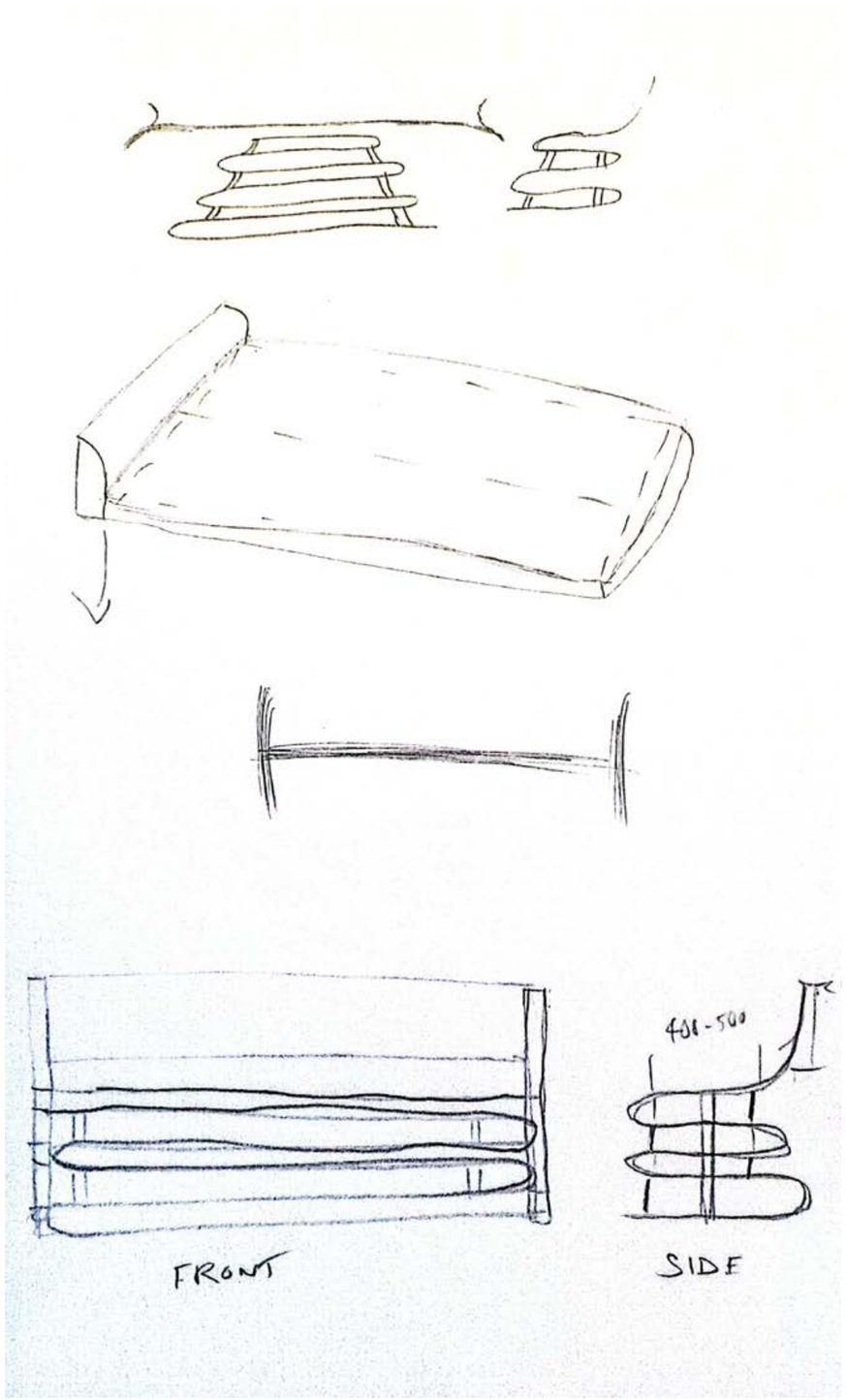






After being mildly hesitant of my chair design, I thought I would attempt some new sketches at exploring other shapes, except instead of using a generic object and pre-existing designs as inspiration, I used the body and movements of a snake to see if I could create something unique and innovative.

Final Concept Sketches and Ideas:



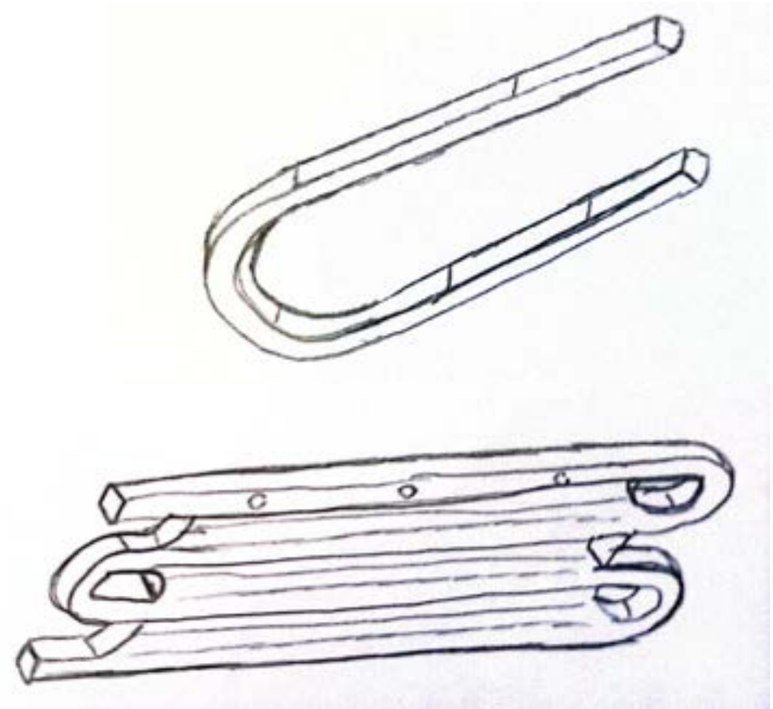
For the sketches on the left, I continued exploring this new snake inspired design. I drew some orthographic views of the project, which led to me transitioning the chair, into a bench.

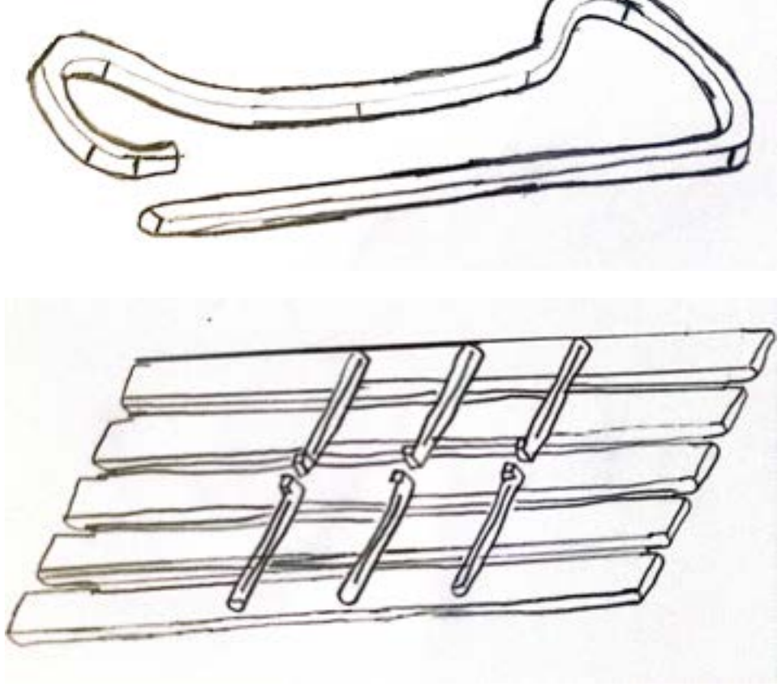
Although the sketches are rough, I had a more concrete understanding of what I wanted to achieve, so I concluded my sketching here, and began using fusion360 for modelling.

The sketches on the right were my last drawings made, which I did to help visualise the individual components before attempting any methods of joinery.

I isolated and drew the parts that I believe could realistically be assembled piece by piece, instead of drawing the entire project.

This helped me gain an understanding of what joints needed to be made, and how they would ultimately look.





Fusion360 Concept Models:

This fusion model was the first iteration I had contructed, which attempts to actualise my sketches in a computer rendered model. I experimented with the base of the design by including the curvature as seen in the image, however, it was not structurally sound from my perspective, so i included a metal frame on the base, which could be wedged into concrete and bolted through.

The seat of the design was fairly unexplored too, as it appeared flat on the base and back, which looks fairly uncomfortable.

I also had concerns with this design, as I was uncertain about how the actual metal shape would bend, and whether this was actually structurally secure, in which I realised later, it wasn’t.

Fusion360 Concept Models:

This is my second attempt at creating the fusion model, which explored the bench more thoroughly in terms of aesthetics, and ergonomics of the seat. Visually, I liked how the bench appeared, however, there were a lot of curves for the metal component, making it once again a difficult shape to attain. Functionally, it maintains its purpose well as a bench, however, the main drawbacks I had towards this design, was that it didn't feel unique, and manufacturing it would be a serious problem.

The reason i found this design to not be unique, was because the legs were situated on the side similarly to how most benches today position their legs. I knew if I wanted to create something unique and different, I would have to overhaul the majority of traditional design.

Market Research and product identification:

At this stage of the design process, I had decided that I would be making a bench that is suitable with all environments. To see how effective my design could be, I researched current available benches for purchase, and questioned peers and friends about how they felt about local park benches near them.

(Bunnings, 2022)

- Natural wood finish adds character to any outdoor space.
- Premium-quality, environmentally-responsible FSC-certified wood.
- Generous proportions and classic design for comfort.
- Easy to assemble, Seats 2 persons comfortably

The contemporary, hard wearing Timber Bench features a natural teak look finish, constructed from solid eucalyptus wood with a striking cross back. This Bench will be an stylish extra for most gardens and patios. Manufactured from FSC-certified eucalyptus wood - a hardwood renowned for its strength and durability, which not only looks great but is also protected from the elements by a premium-quality oil coating which is weather-resistant and also enhances the natural tones of the wood.
The classic design with natural wood finishes not only pairs with traditional decor but also with modern decors, bringing a new touch of class to your space.
Great for your garden or patio, it's easy to assemble with clear instructions and comes pre-treated for weather resistance so you know it will last you through the seasons.
The timber is pre-treated to ensure longer life and resistance to the weather.

Dimensions

	Width	Height	Depth
Bench	565mm	790mm	1180mm

The first available sold bench shown here, is called the Marquee, which is a 1 metre long bench that caters towards home living outdoor furniture. For $139 AUD, this bench is a low-cost piece of furniture, which features eucalyptus timber coated in a hardwax oil, suitable for seating two people.

This bench specifically aims towards consumers that have patios and gardens, marketing it as an opportunity to improve the outdoor space for private use.

The all wood construction also makes me believe that this bench serves no relevance in a public setting, and is exclusively designed for families or people with many guests/visitors.

(Felton Industries, 2022a)

(Felton Industries, 2022a)

This design featured here is the above ground bench seat, which is manufactured by a mass-producer known as felton. Unlike the bunnings design, this seat is aimed towards public use, within environments such as schools, parks, and community centres. The price for a 2 metre long bench such as this begins at $540, with other variants and designs costing upwards of $5000.

Although the price is very excessive, the marine grade aluminium used, will allow this seat to withstand time, making it a long-term investment aimed towards councils, schools, and precincts looking to upgrade and innovate their outdoor seating arrangement.

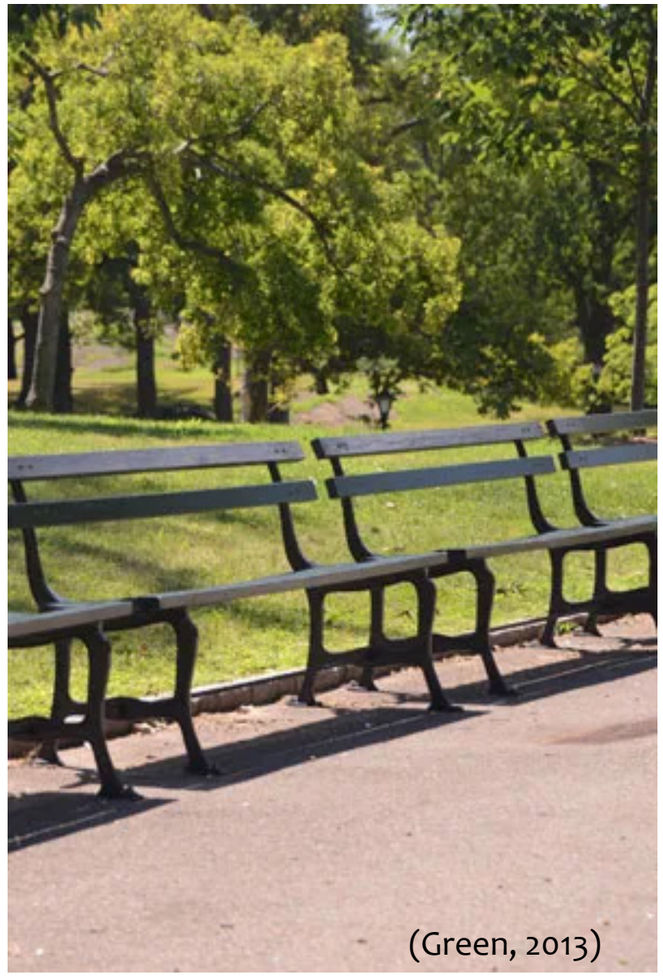
Market Research and History:

In an article by (Stoppard, 2020), the outlook into new modern benches was examined, with the majority of people seeking new concepts and perspectives towards public benches that relate to community use.

Historically, benches were built in plazas, town centres, and small public spaces for theatrical or tribunal purposes (Green, 2013). As long as the bench would be able to seat people, the primary intention would be achieved. However, beggining from the 19th century until the present, benches grew in demand and popularity due to an increasing population. To avoid mass-producing the same flat piece of furniture, newer designs were made, with the 1860s iron garden chair being one of the first examples of a design variation (Green, 2013).

This chairwas lightweight, mass-producable, and felt comfortable due to the shape, making it a popular product for distribution to Africa, Asia, and Europe (Green, 2013). This trend of innovating and designing soon transcended into the 20th century, where Marcel Breuer's famous panton chair was inspired from classic park benches with the use of modern thermoforming plastics (Green, 2013).

In the 21st century now, we are seeing urban bench designs, with the Harvard plaza bench being an example of explorative design that suits the theme of a place instead of just functional purposes (Green, 2013). Although the bench utilises an excessive amount of materials, the visual appearance and layout makes the design a complimentary piece of furniture to the environment around it, giving additional characterstics to the place it is located in.



(Green, 2013)

(Green, 2013)

(Green, 2013)

Overall, after investigating the historical relvance of chairs and how it's perceived in the 21st century, I was certain that I knew what market I needed to aim for, and which one would best respond to my design ideas.
However, I felt like I needed to explore more pre-existing designs to grasp a better understanding on how current companies are advertising their bench, what materials they are using, and the cost of the bench in total.

Pre-existing Ideas and products:

After researching the most appropriate target market, I decided to find the most readily available park benches, and construct a PMI chart to evaluate the aspects I liked, and the parts that could be improved upon.

Design	Plus	Minus	Interesting
Classic Plaza Bench  (Street Furniture, 2022a)	- Uses eco-friendly hardwood or recyclable aluminium depending on the clientele. - Looks relatively easy to construct and assemble. - Utilises stainless steel frames that bend together to form a solid structure. - The wood has been curved so that it looks less blocky and simpler. - The seat also incorporates user moulding, where it curves inwards to feel more comfortable to the user.	- No backrest for Lombard support. - Costs approximately $1500 - $2000 depending on whether aluminium or eco-hardwood is used. - The design mainly highlights the wooden seating aspect and disregards the legs.	- I found it interested that the timber was shaped to fit the general shape of people more comfortably compared to flat planks of timber. - I also found that the overhanging curvature was a nice addition in loosening up the shape of the design, as the legs and wooden planks are naturally geometric.
Classic Plaza Seat  (Street Furniture, 2022b)	- This is another variation designed by Street furniture for parks, where there is a contrasting emphasis between metal and wood. - The shape of the chair is shaped more accurately towards comfortability as it incorporates a back rest. - The design of the seat is also slightly raised on an incline, so that the user can utilise the back rest for efficiently. - It follows the same eco-friendly hardwood, aluminium and steel which makes production easier. - The simplicity of the design along with the sharp colour contrast makes it really appealing, as well as the curves made to mould the seat to the user. - The addition of armrests is also very useful to aid in the comfortability of the user.	- Once again, I felt the legs for this design were overlooked and were lacking. - The seat reminded me of a train station bench which wasn't too appealing. - It requires to be bolted into the ground to prevent theft and maintain structural integrity, which means this bench is aimed primarily towards public design and uses.	- I found it interested that the slightly raised incline would allow for better interaction with the back panel of the seat. - I also found it interesting that the curves the design follows are arranged to suit various people of differing heights.

Design	Plus	Minus	Interesting
Village Bench Design  (The Park Catalog, 2022)	- This design featured a different approach to benches, where the entire product followed a strip/line construction. - The chair is made out of a cast iron frame and strap metal which have been finished in Thermoplastic. - The thermoplastic helps prevent age and decay, and also removes the harshness associated with raw cast iron. - The design features the legs more fluently, and incorporates it as a key focal point of the design.	- The price tag is approximately $2000 with all costs included which is far too high. - The vast iron construction means it does not need to be embedded or bolted into the ground, however, it is extremely heavy to lift or move. - The vertical strap metal opposed to horizontal configurations makes it more prone for people to slip off and feel greater discomfort as there's no gripping points.	- I found it highly interesting how they managed to bend the cast iron into different shapes, and how the thermoplastic was attached to the design. - I also found it interesting that despite how heavy this design is, it feels lightweight and less clunky compared to other aforementioned designs.
Train Station Seat  (Commercial Systems Australia, 2022)	- The entire design is made of steel with stainless steel seats and mild steel/ galvanised steel legs depending on the customisation of the user. - The metallic design is suited towards the train environment which I believe works adequately as the design theme. - It's weather and corrosion resistant depending on the finish of the product which is either galvanised steel or stainless steel. - It can be bolted into the ground, or it can be setup as a regular bench - Despite being designed towards train stations, it is not limited to train stations.	- The harsh metal look makes it seem cold and hard to sit on. - Creating the small holes and shaping the metal may require heavy industrial equipment, especially in mass manufacturing. - The price tag is set at a minimum of $1400 at the base model which increases depending on the configuration. - The monotone silver colour can be offsetting. - The legs have been disregarded within the design, where the only applicable design features are the seat and handle which are only minor curved bends.	- I found it interesting that the bench had holes in the seat, as to whether that's a functional need for bending the metal or an aesthetic design. - I also found it interesting that two different steel coatings were used to finish the seat and legs.
Forma Curved Park bench  (Mmcité, 2022)	- The curved shape bench is designed to suit the surrounds of a park or anywhere that utilises curvature. - Rather than follow body moulded designs, the bench instead warps itself around the environment feeling more naturally suited to the space it is occupying. - The urban contrast between the cast-polished concrete and wooden lamellas makes it feel more natural when placed on a concrete surface. - The use of mild curvature on the legs and timber helps offset the harsh geometry if it weren't there.	- The seat does not follow any proper body moulding, meaning that there is the potential for it to be uncomfortable for varying users. - There's not backrest or arm rest meaning that the utility of this bench is reduced. - Requires multiple benches to suit the design theme, or else a singular bench on its own looks out of place.	- I found it very interesting that cast concrete was used, and that it pairs highly well with the timber. - It's also interesting to see the floating seat design which is apparently supported by hidden galvanised steel frames. - Unlike other singular benches that are their own product, this one can be designed and arranged with multiple variants which in an interesting approach to bench design.

Overall, I found these designs represent various aspects of public out door environments that I would need to factor in when choosing the appropriate design scheme, layout, and materials to use.

A material such as wood in an environment such as a train station would be out of the ordinary compared to exclusively using metal. The same concept applies to using metal in an environment surrounded by nature. The materiality and design need to match the environments it will be in, meaning that I need to consider the most appropriate way to design by bench, and to see whether it can only suit one environment, or if it has the potential to suit as variety.

Identifying the primary and secondary market:

Through evaluating the pre-existing designs, and what the general populace expect from bench designs, I believe that the primary market that I will be targeting my design towards are councils and local governments.

This industrial sector was chosen as the primary market as councils and local governments are constantly involved with maintaining the quality of landscapes for schools, parks, recreational centres, and outdoor living spaces. Rather than individually marketing my bench to a niche individual user demographic, councils and local governments have the ability to exclusively receive my bench through direct contact, which has the potential for mass producability.

By marketing towards these government entities, there's a greater level of exposure for the design, and an opportunity for the project to re-define and innovate how we perceive park benches publicly.

The secondary market that I decided upon was the exterior design market, where wealthier people and companies seeking luxurious outdoor benches can utilise my design for their private uses.

Although there would be some overlap with the design acting as both a private and public bench, the exclusivity of the product to government entities and wealthier people would mean that every bench created is a unique item, and not a simple mass manufactured piece of furniture.

Since the ordinary person would not require a bench on a daily basis, this demographic of wealthier people was chosen as it can be used on golf courses, large gardens, lawn areas, and pools.

Market Field Research:

At this stage in the design process, I had my initial concept sketches made, my preliminary fusion360 drawings made, and an idea of who my target markets were. Using this research and knowledge, I asked peers on the ACU Strathfield campus about my design, and what they thought about it.

Question	Anonymous A	Anonymous B	Anonymous C
What do you think about park benches? Do they excite you?	*I don't know what you mean. I guess they're not really exciting.*	*I think park benches are meant to be sat on at the park when you're out with your dog.*	*Can't say they're exciting. They're just benches, aren't they?*
How do you feel about the quality of benches in Sydney?	*As long as I can sit on them without splintering myself, I'm fine with however they look.*	*Absolutely rubbish. There's either bird droppings on it, or half a plank's missing. Nothing about park benches is right.*	*I've seen some flaky ones these days, but the metal ones are pretty sick, but they are also very cold.*
How do you feel about the look of benches in Sydney? Do you want something cooler looking or not so much?	*Most things that try to be cool turn out to be an awful waste of time and materials. A bench is a bench. You sit on it, and that's about it. Doesn't need to look good.*	*If it's not covered in bird droppings, it probably looks alright.*	*The new ones at Parramatta are pretty sick, especially with the full metal covering the entire playground area.*
I have attempted to innovate bench design and have created a new concept for public park benches. Would you like to see them?	*Yeah I'll take a look at it. Let's see what you've whipped up this time.*	*Oh really? Okay, show me.*	*Innovate Park benches? Does it have an built water bubbler?*
What do you think about these sketches and this CAD model?	*The sketches are really hard to follow without the CAD since I have no clue where you're going with all the line work, however, I think the design looks neat.*	*That CAD model looks really nice, and I like it overall, but what's it going to be made out of?*	*Wow, that's definitely one hell of a bench. It looks massive doesn't it?*
Would you yourself purchase a bench like this?	*Probably not man. It wouldn't fit in my apartment, and even if I had land, I just couldn't see myself using it.*	*Yeah maybe one day if I own a park. The bench is sick and all, but even if this were any other bench, I just don't know what to do with it.*	*Look's really expensive, so I might have to say no, but if I were loaded with money, I probably would just cos of how it looks.*
If you hypothetically worked at the council, would you purchase this for the parks?	*Honestly, with how this looks, I reckon so. Although, it would have to be like waterfront parks.*	*Yeah man, the benches would look pretty sick in most places, and it's definitely something that no one has seen before.*	*I'm only going to say no, just because what would happen to all the other park benches out there right now?*

Overall, it was a mixed review of what people wanted and expected, however, it was certain that nobody personally wanted this design or a bench for their own current use.

Aims for the ergonomics, function, and aesthetics of the design:

For my design to be successful, I intend for it to retain traditional bench qualities such as being able to seat more than 3 people, be made of naturally sustainable materials, and can last for decades on end without aging too dramatically.

To achieve this, I will make the bench top out of timber that is in abundance, such as Tasmanian Blackwood, while also making it between 1.5 metres and 1.75 metres. I will also ensure that the frame of the bench will last for a significant amount of time, while the seats can be potentially modular with the ability to alternate after the slats have aged and deteriorated.

The ergonomics of the chair are unfortunately one aspect of the design that have forcibly been retracted from since the government DDA act prevents any significant modifications to a standard flat seat.

Fortunately, it is still acceptable to create a slight arc within the seats, which is what I will use to make the design feel more inviting and comfortable in comparison to flat unfinished slats.

Aside from the seat use, I also want people that use prams or trolleys to be able and park their items next to the bench without it being a nuisance or a hassle.

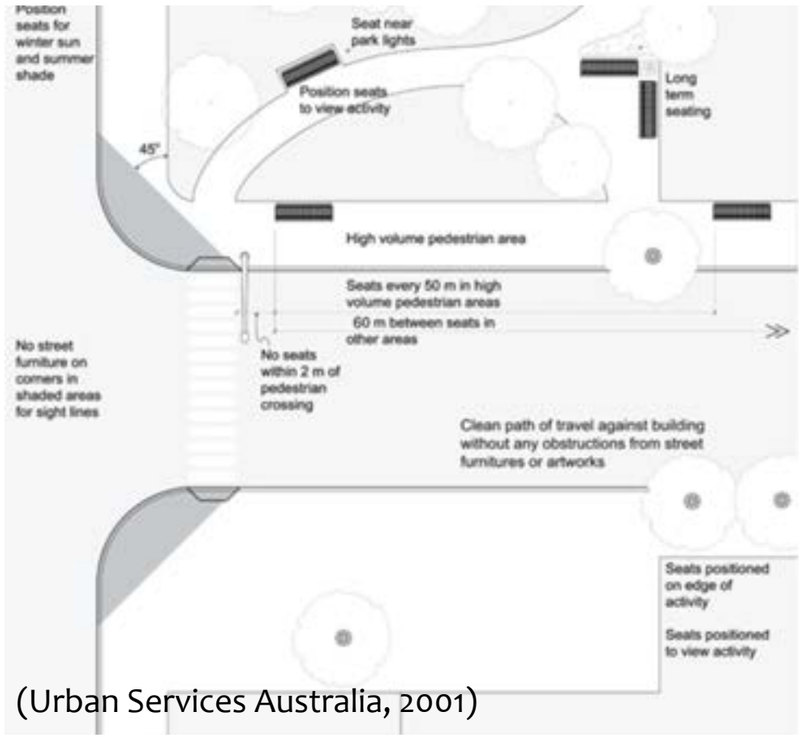
In terms of aesthetic design, I intend for my snake design theme to take precedent as the key piece that draws onlookers to my bench. Instead of incorporating a generic shape alteration to a standard bench, my aesthetic approach to this bench design is to be flamboyant and direct with how I present this bench to the public.

I will also ensure that the aesthetic elements at play will not interfere with how the bench functions from a usability standpoint.

Legal requirements and bench regulations:

For outdoor public benches, there are various policies and guidelines in Australia that need to be adhered too before a product can be distributed for the public to use. Most notably, the Design Standards for Urban Infrastructure (Urban Services Australia, 2001) is the primary guide that all states and territories in Australia follow.

This regulation guideline document in relation to benches, highlights how bench seats and design need to be appropriate for the environment that it will be placed in (Urban Services Australia, 2001). Benches should also factor in the demographic, the amount of people that traverse through a specified area, and what type of activities people do in that area (Urban Services Australia, 2001). Seats should also offer a range of different heights with and without armrest to provide for a greater portion of people (Urban Services Australia, 2001). Seats cannot be placed near the sides of busy roads or junctions, and cannot be placed in a location that disturbs pedestrian activity (Urban Services Australia, 2001). Seats with a durable finish made out of metal are highly recommended, with seats also required to have ample space between slats to remove excess water from rain (Street Furniture Australia, 2019).



(Urban Services Australia, 2001)

Seats must be designed to avoid entrapment hazards according to Australian Standard AS 19242, and Design Standard 15 (Urban Services Australia, 2001).

According to the Ballarat Street and Park furniture guidelines (City of Ballarat, 2013), a few additions were added into ensuring bench standards are maintained in Victoria. Guideline 6 highlights how benches should avoid being placed in front of heritage buildings, as it draws too many crowds, potentially acting as a risk to the heritage site (City of Ballarat, 2013). Guide 2 of aims and issues describes how benches must use a woodland grey colour for painted finishes within streetscape environments (City of Ballarat, 2013). This guideline aims to prevent the benches from changing the environment of the city, as all other outdoor establishments such as bollards, bins, and shelters are also coloured the exact same. Newer benches are recommended to utilise recycled products, since it's more environmentally sustainable, and reduces the eco footprint of the state (City of Ballarat, 2013). Wood plastic composite is the most suitable material designers should be working with, as it's sustainable, durable, and the colour scheme can be altered to suit the environment it is in (City of Ballarat, 2013).

The disability discrimination act of 1992 (DDA) is a law that requires designers to consider and recognise the relevance and importance of disabled people within a outdoor setting (Street Furniture Australia, 2019). More specifically, design standard AS1428.2 states that the seat height, including the backrest, should not exceed 790mm (Street Furniture Australia, 2019). Although this may impede on comfortability, the government of Australia prioritises accessibility, especially seeing how a complicated design would make it difficult for a disabled demographic, or elderly people in general (Street Furniture Australia, 2019) . If the seat is not flat in at least 2 directions, armrests are a must to include on the design (Street Furniture Australia, 2019). The seats themselves should be 400-485mm high, while being able to accommodate for a wheelchair or pram to fit nearby.

Using these recommendations and regulations, I ensured that my bench design followed these ideas, so that I could produce a quality product that would be marketable.

Materials, processes, and resources, investigation, analysis and justification:

Materials	Plus	Minus	Interesting
Stainless Steel	- As an alloy of nickel, iron, carbon and chromium, stainless steel has been referred to as “rustless steel” in the past when it was first discovered in the early 1900s (Sherwood Steel, 2018). - The material is highly resistant to oxidation and corrosion due to the addition of resistant properties such as the chromium layer, as well as the nickel providing metallurgical stability to the alloys (Sherwood Steel, 2018). - Stainless steel also retains its hardness and durability, while also having a very high melting point, which makes it versatile in various construction and machine-operated industries. - The finish of stainless steel is very reflective and shiny which can make it an attracting feature for people to see (Sherwood Steel, 2018).	- Due to the durability and high abrasion-resistance of stainless steel, it is harder to work with when cutting or attempting to bend it (Metal Supermarkets, 2018). - The high thermal resistance also makes it more difficult for welding to occur too - Stainless steel does not operate the best outdoors for too long as most steel which is 304 grade, is not built for long-term exposure to the elements (Metal Supermarkets, 2018). To solve this, 316 stainless steel is used, which incorporates more alloys such as silicon, manganese, and higher chromium, which allows for a chloride-resistance and overall better protection from oxidation (Metal Supermarkets, 2018)	- The thermal resistance of stainless steel is interesting since it instead requires an enormous amount of pressure or force to make it bend, however, it is still possible to weld albeit slightly difficult (Metal Supermarkets, 2018). - It’s also interesting to see the various applications stainless steel has within an environment, as it’s used in kitchenware, construction, and furniture quite often (Metal Supermarkets, 2018).
Galvanised Steel	- The galvanised steel is coated in zinc which gives it resistances to rust, corrosion, and outdoor wearing (World Iron & Steel Co.,Ltd, 2017). - The coating of zinc usually lasts around 50 years to 75 years depending on the environment, which makes it a formidable material in the outdoors. - Requires less maintenance compared to a painted steel since the zinc doesn’t wear away fast. - Easy to prepare and setup since you don’t need to add primers before coating, and inspecting its structural integrity is easier since you only need to assess the sturdiness of the steel, and the thickness of zinc coating on it.	- Since the zinc isn’t integrated within the steel, it primarily protects the outside, meaning that the inside is susceptible to internal rusting and corrosion. The is preventable however, by sealing the openings (World Iron & Steel Co.,Ltd, 2017). - Over time when galvanised steel corrodes, the metals can seep into the earth and nearby water supplies with may be a potential environmental issue (World Iron & Steel Co.,Ltd, 2017). - Galvanised steel despite being a strong and sturdy structure is susceptible to dints, scratches, and damages if taken care of poorly or if it’s abused (World Iron & Steel Co.,Ltd, 2017).	- It’s interesting how the zinc coating application is able to extended the lifespan of the steel, so much to the point that creating a design with galvanised steel could potentially last an entire century. - It’s also interesting how affordable yet strong the material is.
		- Galvanised steel can once again be difficult to work with when cutting due to its strength, and even more so welding, as the galvanised steel exhibits toxic fumes when heat is applied (World Iron & Steel Co.,Ltd, 2017). To avoid this however, creating a structure before the galvanised coat is added prevents any toxic fumes (World Iron & Steel Co.,Ltd, 2017).	

Materials, processes, and resources, investigation, analysis and justification:

Materials	Plus	Minus	Interesting
Timber Pine	- As a softwood in high abundance within Australia, Pine wood is cheaper than most hardwoods, it's light weight, and very versatile in construction (Wood Solutions, 2022). - It is also resistant to shrinking and welling, has good elasticity, an attractive grain, and does not need any reinforcement to hold the material together (Wood Solutions, 2022). - Despite being a softwood, it is quite a strong material with high compressive and bending strength (Wood Solutions, 2022). - Pine is also easy to work with and won't decay your tools over time compared to hardwoods due to how the grain and structure is composed (Wood Solutions, 2022).	- Some disadvantages of pine include how easy it is for it to be torn up, especially in a moist environment (Wood Solutions, 2022). - Pine is also known to dent and scratch very easily even after a finish has been put on it. - It has less strength compared to other hardwoods, and its lifespan is also significantly less with it ranging between 5-25 years if looked after well (Wood Solutions, 2022). - Pine is not water resistant unless it's sealed, and is also more susceptible to rotting, termites, and decay (Wood Solutions, 2022).	- It's interesting to see how easily pine can be constructed to suit a variety of shapes and sizes, while also being a lot easier to construct and glue together. - It's also very interesting to see how the application of treated pine is widely used within the housing and construction industry for creating frames.
Plywood	- Laminated timbers such as plywood are a widely versatile material that can best be used in an industrial setting such as construction (He et al., 2020). - Exterior plywood for example is a high-quality rugged choice for panelling the outside of a house, or creating a shed, since it's weather-resistant, robust, and the glue that binds the wood together exhibits moisture resistance which aids in preventing rotting and water absorption (Banerjee, 2021). - The addition of a treatment to seal the plywood also greatly assists in extending the lifespan of the material (Banerjee, 2021). - Interior plywood comparatively is constructed to be smoother and less bulky, with relatively good strength and less thickness than exterior plywood (Banerjee, 2021).	- The lifespan of plywood in comparison to hardwood is significantly less with it ranging between 3 and 10 years for outdoor use (Banerjee, 2021). - Plywood can also feel cheap if a low-grade quality is used, or if it isn't finished appropriately (Banerjee, 2021). - The structure of plywood is also less durable and strong compared to hardwoods as there isn't any grain along the timber, and solely relies on other laminated sheets to add strength (Gaywood, 2020).	- Plywood is an interesting way of using thing layers of timber and piling them on top of one another to create relatively strong structures. - It's also interesting to see how popular plywood is in stores such as Bunnings and Mitre10 with it being used for a range of different purposes such as flooring, and walls.

Materials, processes, and resources, investigation, analysis and justification:

Materials	Plus	Minus	Interesting
Tasmanian Blackwood	- Tasmanian Blackwood is an abundant natural hardwood from the wattle family found in North Queensland, South Australia, and wetter areas of Tasmania for larger volume (Tasmanian Timber, 2005). - The timber itself appears in various colours from light brown to dark brown occasionally with black streaks within the wood. Blackwood is worked with easily, long-lasting, and is very durable in the long-term (Tasmanian Timber, 2005). - Due to how easy blackwood is to grow, it is one of the richest materials in Australia making it a sustainable choice in timber design (Tasmanian Timber, 2009). The texture of the blackwood is known to be even and medium, while the grain is typically straight with occasional waves depending on source of timber (Tasmanian Timber, 2005) - Tasmanian Blackwood also adheres to glue and resins more easily due to the exposed grain, and is also a less expensive hardwood as it is considered an invasive species (Tasmanian Timber, 2005).	- Tasmanian Blackwood can be a bit hard to work with due to its strength and grain structure (Tasmanian Timber, 2005). - Depending on the type and quality of Tasmanian Blackwood, it can be mildly expensive, and the growth rate of the trees often takes 20 years minimum (Tasmanian Timber, 2005).	- It's interesting how abundant an popular the material is, and to see it being used in furniture and decking demonstrates how effective the material is. - It's also interesting how as an invasive species, Australia essentially has a highly populated supply of blackwood which can be used or sold off.
Cast Iron	- Cast Iron are iron-carbon alloys where the carbon content is greater than 2-4% (Sabhadiya, 2015). - Cast Iron in addition contains smaller amount of silicon and manganese which aid in increasing the tensile strength of the material albeit still low compared to other metals (Sabhadiya, 2015)	- Cast iron is weak to acids and is known to be prone to rusting and long-term degradation (Sabhadiya, 2015). - It has poor tensile strength and poor machinability compared to a metal like steel (Sabhadiya, 2015). - Poor Impact resistance and high brittleness means that the cast iron	- Cast iron being used outside of its thermal properties is interesting especially outdoors, since modern materials such as Stainless and galvanised steel tend to outshine it, making cast iron a unique choice.

Materials, processes, and resources, investigation, analysis and justification:

Materials	Plus	Minus	Interesting
Cast Iron	- Cast Iron are iron-carbon alloys where the carbon content is greater than 2-4% (Sabhadiya, 2015). - Cast Iron in addition contains smaller amount of silicon and manganese which aid in increasing the tensile strength of the material albeit still low compared to other metals (Sabhadiya, 2015) - Since cast iron is poured from a liquid state and hardened into crude ingots known as pigs (Sabhadiya, 2015), they are then forged and created into the ideal shape. - Although cast iron is considered to be relatively brittle (Sabhadiya, 2015), it has many properties that make it desirable as a material. - The hardness of iron via heat treatment makes it incredibly durable, while the toughness it retains allows it to absorb energy more easily (Sabhadiya, 2015). - Cast iron is also very malleable when stressed, as it is quite an elastic metal when attempting to be formed (Sabhadiya, 2015).	- Cast iron is weak to acids and is known to be prone to rusting and long-term degradation (Sabhadiya, 2015). - It has poor tensile strength and poor machinability compared to a metal like steel (Sabhadiya, 2015). - Poor Impact resistance and high brittleness means that the cast iron needs to be taken care of or protected by other materials (Sabhadiya, 2015). - Cast iron is also very heavy despite its weaker strength, making it an awkward material to manoeuvre and work with (Sabhadiya, 2015).	- Cast iron being used outside of its thermal properties is interesting especially outdoors, since modern materials such as Stainless and galvanised steel tend to outshine it, making cast iron a unique choice.

Adjusting the initial design concepts and ideas:

At this stage of the design process, I had significantly changed the design from a chair into a bench. Through weeks of understanding the materials, market, and purpose for the design, I have altered the Design Brief, Aim, and Need, to better suit a more informed intention.

I'm primarily altering these aspects, as the original intentions are no longer relevant to the design, and I want my future test, prototypes, experiments, and final product to be able to reflect these revised goals.

The Design Brief:

Benches have often been placed in the dark in terms of furniture design compared to more predominant forms of furniture such as chairs and seats, since it relates primarily to public and multi-person use (Green, 2013).

Within this design, I will attempt to create a design for a bench that feels unique, luxrious, and modern, which can be used for public outdoor uses, but also for personal private use no matter the location.

The Aim:

To design and create a 21st century modern take on park benches in the hopes of producing a design that explores and expands on current pre-existing designs.

By exploring a wide range of materials and processes, determining the most appropriate way to create this project will be identified. This will also be achieved through the use of attempting sample pieces and joinery techniques, while also constantly evaluating every design decision being made.

The Need:

Since bench design is an aspect of design that doesn't typically realte to an individual personally, it is a fairly unexplored aspect of modern design (Foderaro, 2013). Compared to bench design of the past, benches have relatively improved in terms of materiality and construction (Foderaro, 2013), however, the fundamental flaw that still exists is the visual appeal of a bench within an environment such as a park, roof terrace, or school (Foderaro, 2013).

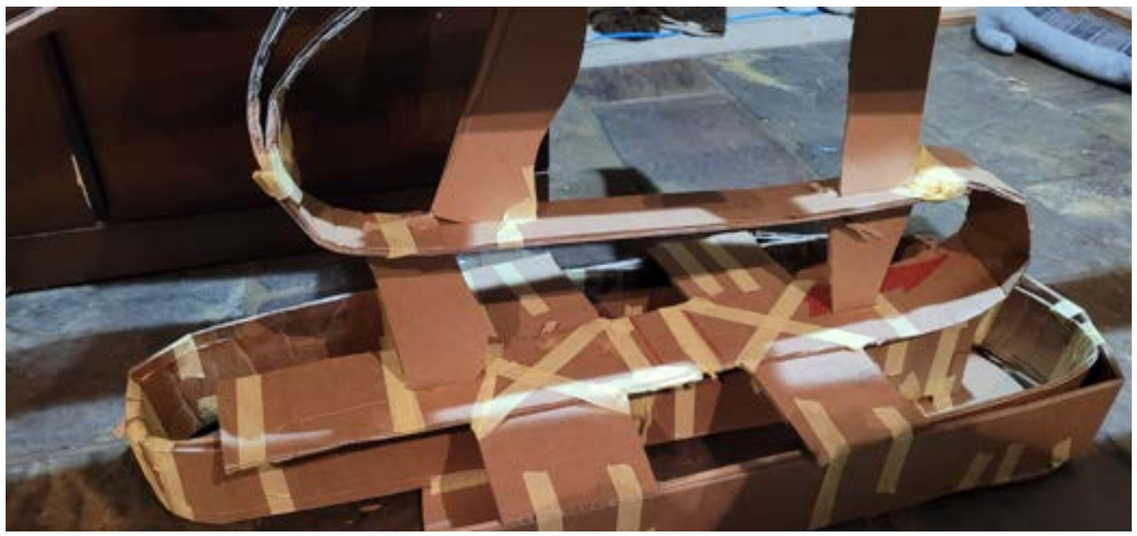
Unlike a couch which is specified to home-living environments, or a stool which can be used for painting or playing an instrument, benches are a niche that are aimed towards multi-purpose utility. This is why I intend to broaden bench design so that it has a suitable place within not only public environments, but also private and personal use as well.

Intended Design and Fusion Model:

After redesigning the fusion models, I was happy and satisfied with this iteration. I could visually see the pieces of metal being welded together, while the seat could be bolted into the metal. I reduced the amount of curves in comparison to my prior designs, and i moulded the seat to look and appear more comfortable instead of having a flat surface.

I didn't want to waste any time, so I used this model as if it were my final one, and began testing and experimenting with prototypes and sample methods of joinery.

Joinery Samples and full-scale mock up:

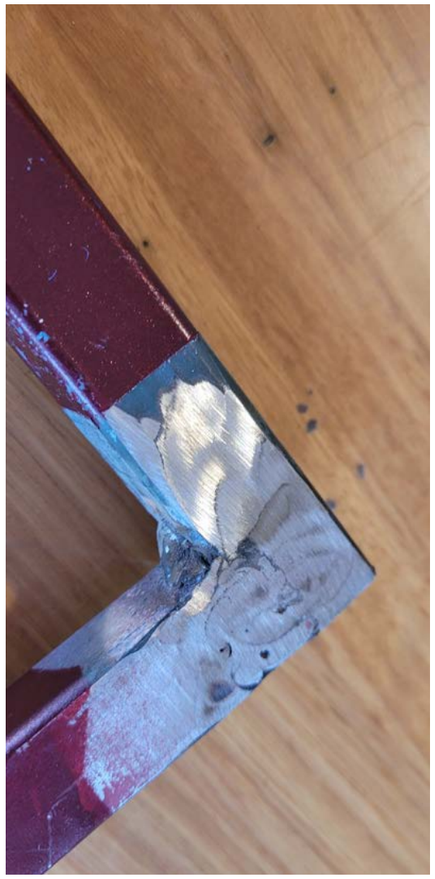


After completing all of my sketching and had a CAD model ready, I prepared this prototype to get a feel of what the intended design would look and feel like. This mock up prototype attempts to create the curves within my design, however, it unsuccessfuly was unable to hold its weight, let alone anything on it.

This model was highly useful however, as this led to me adjusting the length to be 1.5 metres instead of 1.75 metres, and the height also gave me a feel for how low the government regulations would allow me to set the bench height at.

Joinery Samples and full-scale mock up:

Cold bending is a process within metal working that is performed by using rollers to press a piece of steel against a metal shaping tool known as a die (Sen et al., 2008). The pressure provided by the user in conjunction with the fulcrum and arc being made, allows flat bar pieces of metal, and even hollowed metals to be bent effectively (Sen et al., 2008). The only downside however, is that the metal buckles, and warps inwards, as seen within this test.
Structurally, the metal bar is relatively compromised due to the buckling, however, it is still adequate and safe to use so long as other components of the furniture are able to offset the buckling (Sen et al., 2008).



As seen here, this piece of steel was in fact two separate pieces that were stick welded then angle grinded back to reveal a cleaner and more smooth finish.

Typically, stick welding involves using a an electrode with an electrically powered machine, which interacts with the majority of available metals (Fronius, 2022). Compared to MIG welding, this stick welding process was a lot easier, however the welds at times were not as strong as I would have liked, since the metal did fall off on occassions.

This image here is an example of a MIG weld, which was one of the most fundamental pieces of joinery within this entire project. Unlike a stick welder, a MIG welder operates with the addition of a shielding gas such as argon, which helps protect the wire electrode as it forms an arc on the materials (TWI-Global, 2020).

From this test, the MIG weld performed was exceptionally strong despite the rugged look. I first tested stick welding with this joint, however, it was not strong enough and kept falling off.
The MIG weld was more difficult to use, however, the final result yielded a success connection between the two pieces of steel.

Joinery Samples and full-scale mock up:

As seen through this image, the steel was kerfed via a bandsaw. Although kerfing metal is not a popular form of bending metal on an industrial scale (Esabna, 2022)26, for this project it worked effectively as i was able to create minor bends in the design which would contribute towards making the complicated curves.

The kerfs were a bit rough, and at times it did not want to bend all the way, however, I finished off the kerfing with some more stick welding, which was then grinded back using the angle grinder.

This image highlights the use of stain varnish as a finish. There wasn't a specific reaosn I chosen the stain varnish, other than it being the most readily available finish that I could find for outdoor timber use.

The varnish was intially sticky, however, after rubbing it in to the timber, it started to smoothen out. The timber finish was also sanded down to 600 grit for cleaner finish.

Hardwav oil was a consideration at the time instead of varnish, however, I felt that an oil would make this bench too slippery, especially for public use.

This image is an upclose photo of my timber being connected to the steel frame using a bolt. Brackets were an option that I had, however, I didn't bother exploring it since I knew bolts into the timber was a far better and efficient.

The bolts ended up being very strong as I couldn't budge the timber at all after trying to move it.

This image highights the holes I drilled into the base of the timber. The same sized drill bit was also used for drilling into the metal components, although it was chieved using a metal drill press.

This joinery method was successful, as I also used the mortising machine to make the head of the bolt sit proud with the actual timber seating.

Joinery Samples and full-scale mock up:

This is another example of metal kerfing, however this time, I decided to invert the kerf and spring ti backwards, which would allow for sharper curves to be made with less kerfing required, but at the cost of structural integrity.

i was also nervous that the kerfs would be unable to weld due to how thin they appeared, yet I held onto this idea as I believed it could potentially have a purpose somewhere within the design.

Finally the last test I performed was seeing whether spray paint was a possibility within this design. In the circumstance galvanised steel was too harsh of a colour for an environment, spray painting the legs of this design would be an adequate way of adjusting the design to suit a specified need. After three layers of paint, I was ultimately left with this paint job, which did not flake, scratch, or crack.

I specifically used metallic paint meant for cars, as it adhered the best and dried realitvely fast compared to other paints such as enamel.

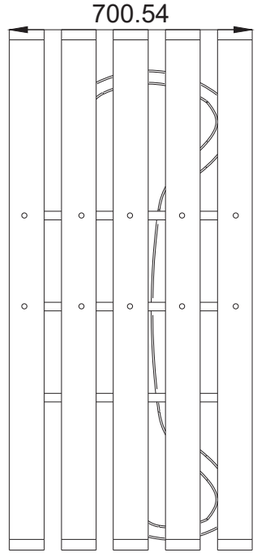
Fusion360 Final Renders and Design:

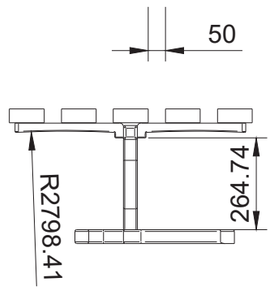
These renders are the final models produced out of fusion360. After modifying the last previous design, my testing and experimentation revealed a few minor changes.

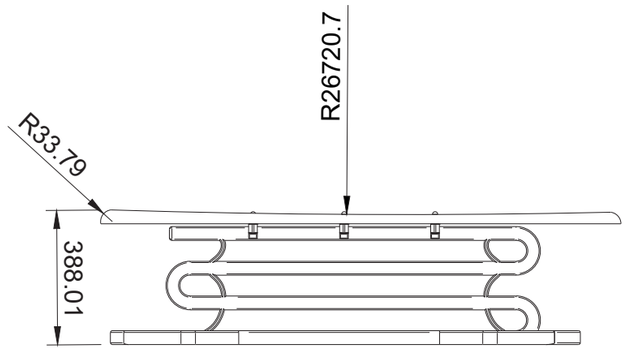
One change included removing the excessive cast iron bracket to hold the bench up, as it was a waste of materials, and was impractical. The other change in the design was creating a notch for the legs, as my mock up prototype revealed users constantly hitting the metallic legs, which I did not want to keep happening.

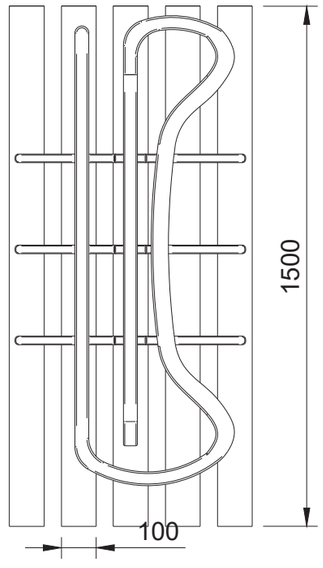
I also included the galvanised bolts that will be used within this design, and I have used these images as Hero shots for the finished product.

Parts Drawing:









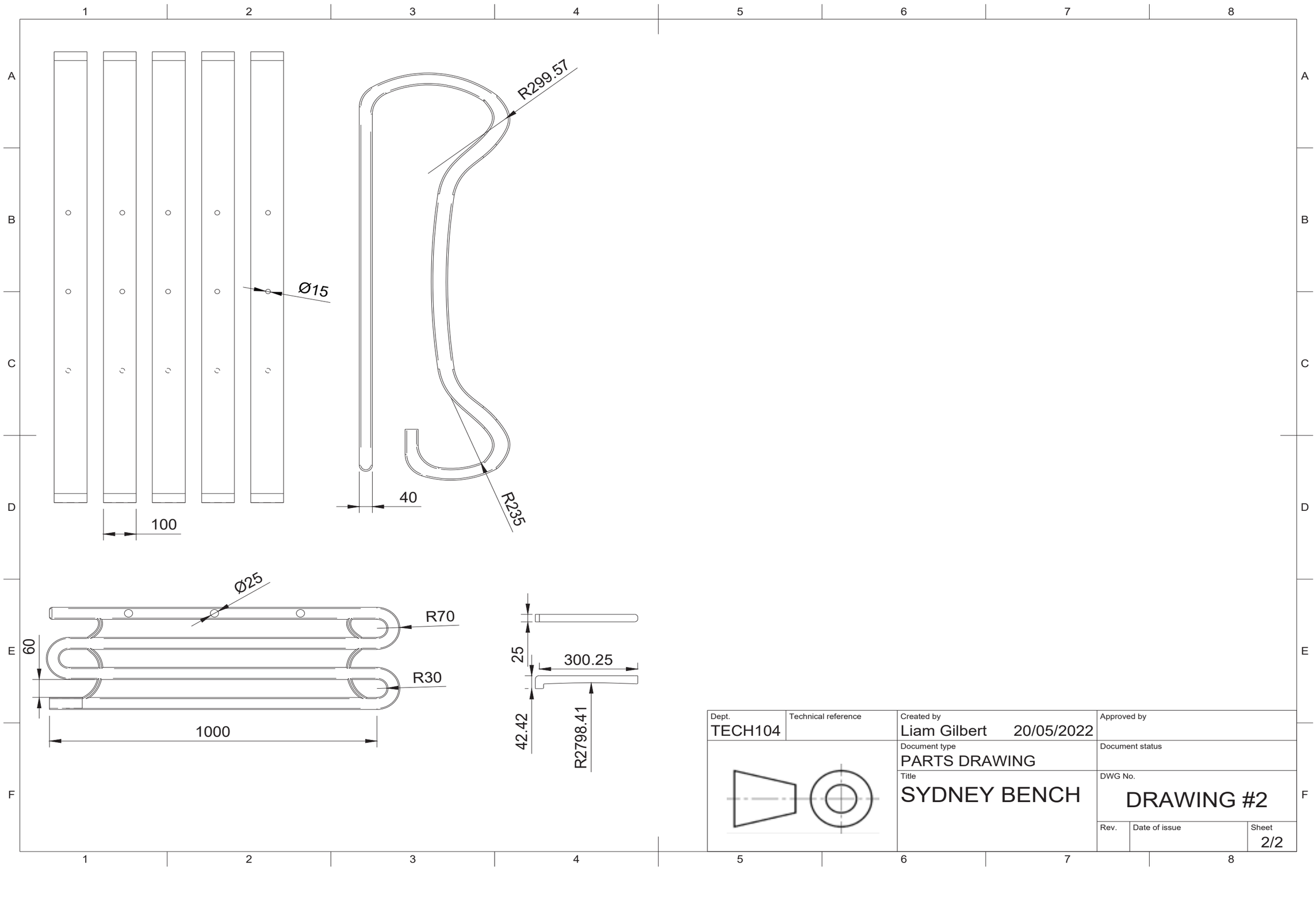
RENDERED DRAWING IS NOT TO SCALE

NOTES:

SCALE IS SET AT 1:15
ALL MEASUREMENTS ARE IN MM
BASE OF THE PROJECT IS MADE OF STEEL
STEEL JOINTS ARE MIG WELDED
BOLTS USED ARE GALVANISED STEEL

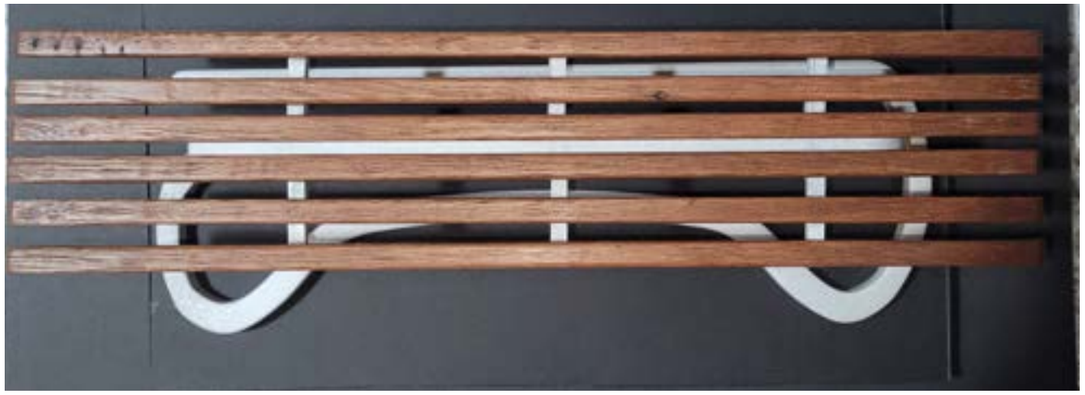
Dept.	Technical reference	Created by	Approved by
TECH104		Liam Gilbert 20/05/2022	
		Document type: PARTS DRAWING	Document status
		Title: SYDNEY BENCH	DWG No.: DRAWING #2
			Rev. / Date of issue / Sheet: 1/2

Parts Drawing:



Dept. TECH104	Technical reference	Created by Liam Gilbert 20/05/2022	Approved by
		Document type PARTS DRAWING	Document status
		Title SYDNEY BENCH	DWG No. DRAWING #2
			Rev. / Date of issue / Sheet 2/2

1:5 Scale Model and the creation process:



As seen in the images, this was the final outcome of the 1:5 scale model which i had prepared. Initially, I was going to 3D print everything for convenience and ease, however, I thought it would be a better experience to explore using other materials that are more realistic for the actual model. Overall, I am satisfied with how this model turned out as it depicted what I had constructed in the fusion drawing. A few aspects of the model such as the support structures holding the planks, could have been cleaned off a bit better, however, it still represented my idea well.

To construct this model, I first uploaded the base components drawing file into the 3-D printer, where the individual pieces are printed via a PLA filament. This took approximately 12 hours to complete, as there were many different parts, and the project was fairly larger within the printer. While the 3D printed components were printing, I used the opportunity to take a piece of scrap tasmanian blackwood, and measure out the dimensions onto the underside. I then used a bobbin sander to create the slight arc within the timber, and then used a disc sander to round the edges of the wood. Once this was completed, I used the measurements marked out from before, and cut the timber on a panel saw to the given lengths. I sanded each piece of timber from 120 grit to 600 grit, which allowed it to feel smoother, while also removing the harsh edges made by the panel saw. I then added a layer of teak coloured stain and varnish, and then let it dry for 6 hours.

By the time I returned to the workshop, my 3D prints were completed, and my timber was dry. Since the timber had already been finished, I sanded my individual 3D components. From 120 grit to 600 grit, this process took me 4 hours to complete as the surface area of the legs was large. Once it was sanded, I added a layer of spray primer which helps paint adhere to the material once applied. After the spray sprimer had dried, I added my first coat of satin steel. Once dried, I added my second coating, and then on the 3rd coat, I modified to nozzle to make it spray abruptly in an attempt to mimic a galvanised steel pattern. Fortunately, it worked, although it wasn't as recognisable as I would have hoped it was.

Finally, I combined all my leg pieces using super glue, and further super glued the timber individually to the legs. I also super glued the entire project to a piece of foamboard, since I believed it looked more presentable and professional.

Actual product manufacturing process:

To construct the actual piece of furniture, I devised a series of steps from my testing and experimentation which will allow for the prouduct to be made.

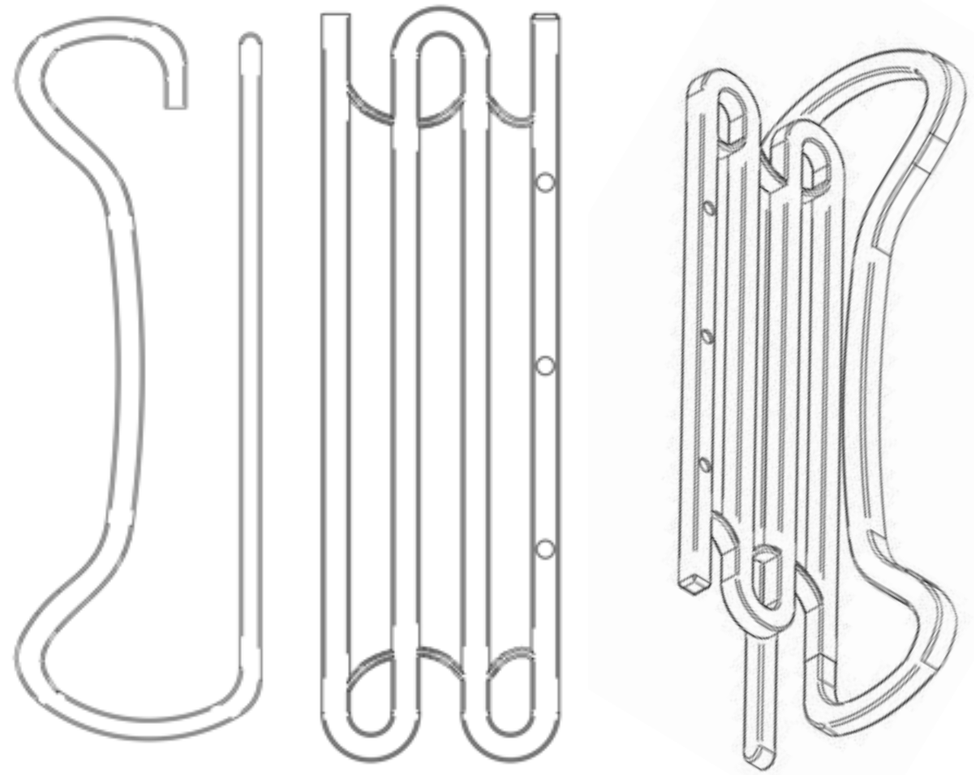
To construct the actual piece of furniture, I devised a series of steps from my testing and experimentation which will allow for the prouduct to be made.

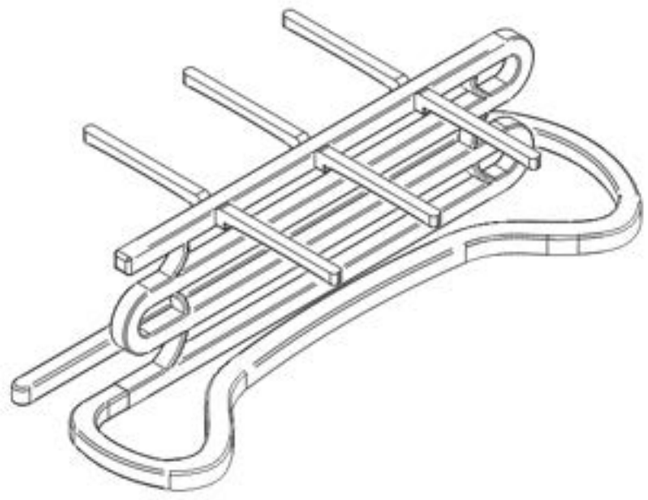
First, all the measurements for the items relate directly to the parts drawing. Using a four metre long piece of steel, cold bend the larger components of the steel base to create the large arc, while the sharper arcs can be achieved through kerfing the metal, and welding it together.

For the centre piece of the bench, shorter pieces of metal can be kerfed and bent to 180 degrees, which will then allow you to MIG weld it to straight pieces of metal. The support pieces of metal can be cold bent and MIG welded in too. Depending on how well done the weld is, an angle grinder can be used to finish these welds off. The support pieces that will hold the timber also need to be made using a metal badsaw and angle grinder to finish, which can then be welded to the centre piece of the bench.

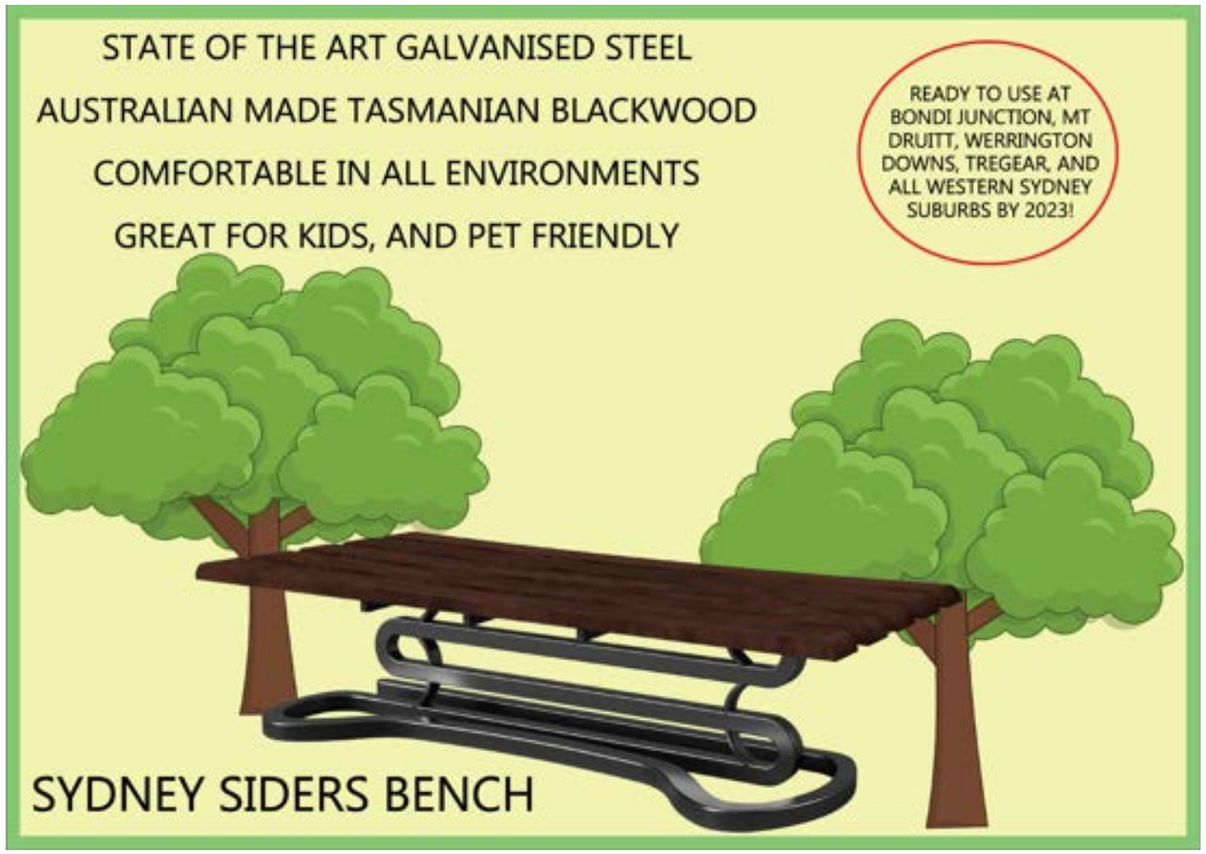
The centrepiece is now able to be welded to the base of the bench, which should yield the primary structure of the design. The timber separately used Tasmanina Blackwood, that has been ripped to equal length, and then finished with snadpaper and varnish. A timber drill press will be used to drill holes into the timber, which will allow for the bolts to fall through. The timber will lso require the use of a plane and orbital sander to assist in creating the slight arc for the design.

The position of the bolts on the timber will also mark out where the holes for the steel will need to be drilled, as the two items will begin to be connected to one another. After using a metal drill press to drill the holes into the steel, the timber seat can be added and locked into place.





Modes of advertising the product:

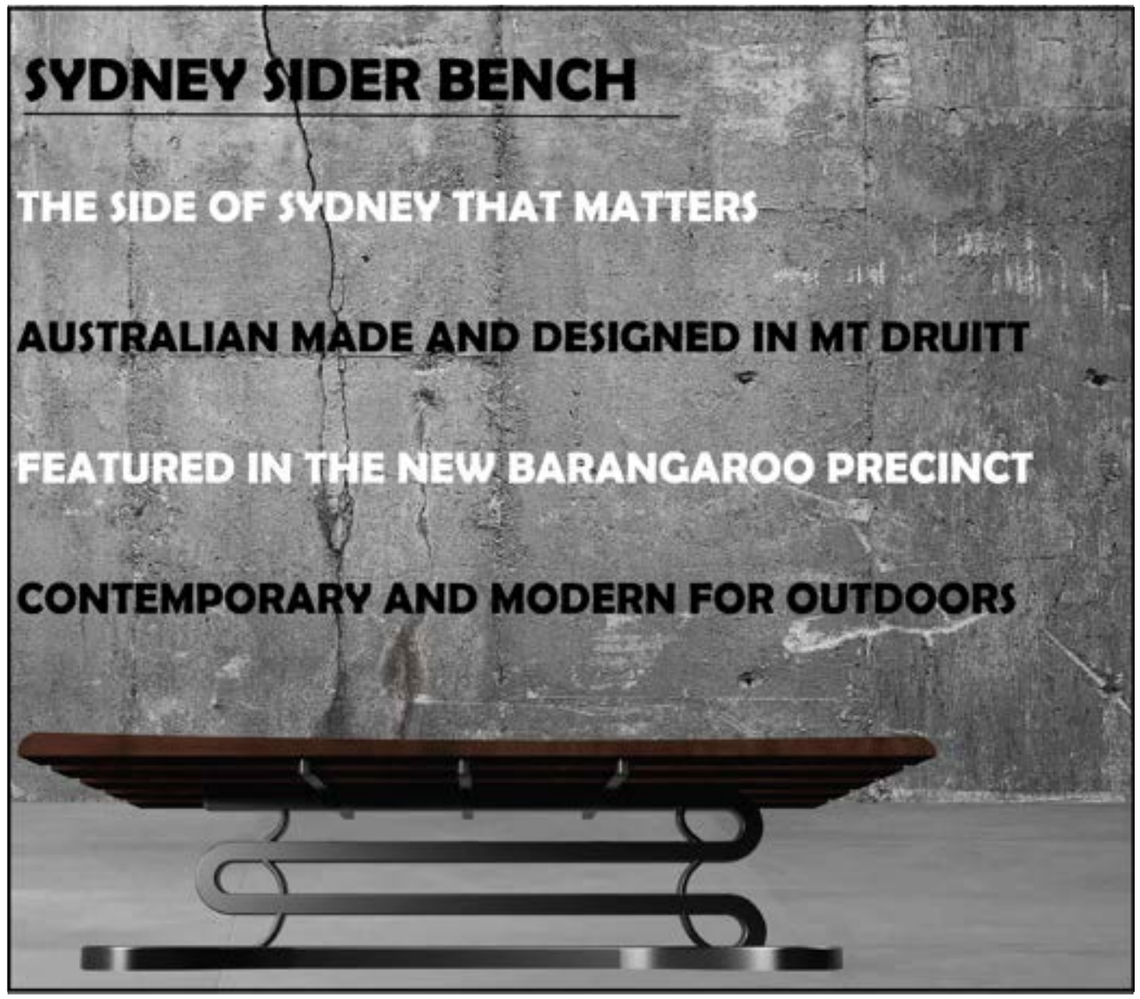


This image provided above was my first iteration and idea when it came to advertising this bench. I kept it simple with tree cliparts, and made it look eyecatching.

Unfortunately, it isn't as refined as I would have liked it to be, and the poster does not really excite me when I look and read it.

This image below was my next attempt at creating a poster highlighting my design. This time, I used a concrete backdrop to demonstrate the industrial approach to my design. I also contrasted black and white text with one another, in an attempt to catch peoples attention.

Once again, I wish it were more refined, and if I had chosen a better viewing angle for the model image, it may have looked better.



Modes of advertising the product:

This is the last designed poster I made, which showcases minimal words, but instead relies on the visibility of the benches within a park environment.

This poster was designed to excite people with a practical look of how the benches could work within an outdoor environment, however, I felt the image wasn't highlighting any specific part of the design, and was instead generalising the entire bench as a whole.

All three posters did give me the opportunity to market and advertise this bench as the "Sydney Siders Bench", which helps give an identity to the design. I named it the Sydney siders bench since the curves made on the legs can mark out two letters of "S".

Evaluation Sheets of the design:

Critical reflective evaluation or analysis of design development samples:

Introduction to the project:

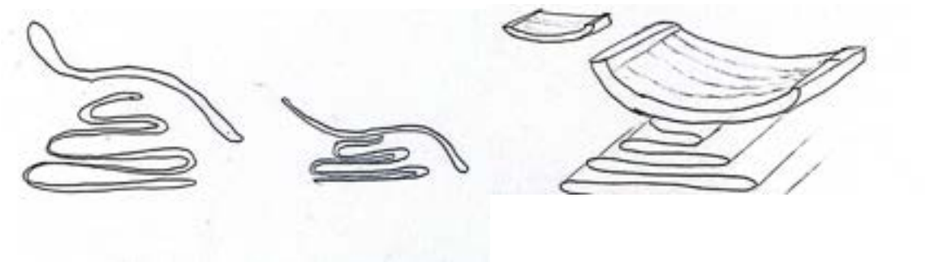
For this project, I decided to create a bench that attempts to innovate and explore a contemporary approach to how we visualise bench design in the 21st century. Unlike chairs, lounges, and sofas, benches are a relatively unexplored aspect of design since they are primarily used in public settings and are disregarded since they can appear to have no direct relation to an individual or user (Foderaro, 2013). I was intent on changing this perception of benches, so I made an attempt to create the "Sydney Sider Bench", which is inspired by 1960s curved architecture and design.

The following images are a render of what the project appears like in Fusion360, and the actual 1:5 scale model outcome, which shows a real-world scale of the actual design.

1) What were you expecting when you thought up your initial design?

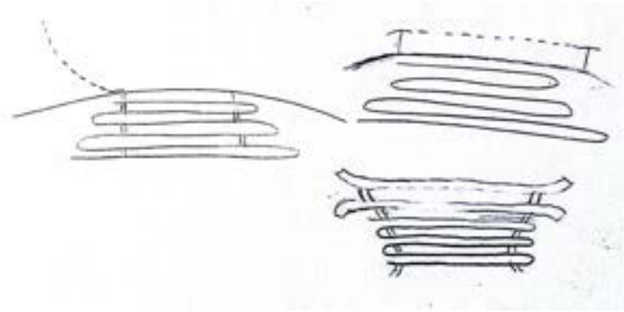
When I originally thought of my design, I was influenced by the curvature and form that a snake would exhibit. Although snakes can be frightening reptiles, the way a cobra and eastern brown snake would position themselves when idle and in a fighting position, looked very intriguing to me. Due to this, I intended to design the project around highlighting this theme, to achieve what I was imagining.

Initially, my design began as a regular chair without any thought about what it would become. Only by exploring pre-existing designs, concept sketching, and research, did I finally end up with my snake inspired design. I first incorporated my snake theme/ curved furniture theme into a chair, as seen through the following rough sketches.



The idea was to feature this theme as much as possible, while having it blend in with the actual seating of the design. I researched existing chair designs that were inspired by animals and reptiles, which gave me an idea of how I should approach designing my chair. Through various sketches and design variations, I thought that I had made a valid design that could possibly work. After showing the design to some peers for feedback, they all seemed enthusiastic towards the design, however, I personally felt that I prioritised the theme and aesthetic element of the project, and neglected ergonomics and functionality. One of the main reasons I felt this, was because aside from the themed aspects within the design, it was essentially just a regular chair with no proper innovative or unique characteristics. I then redesigned my idea into a longer chair that could have more functional uses, while drawing away from the heavily inspired snake theme.

As seen in the following images, I redesigned my project to incorporate greater functionality and ergonomics within an outdoor environment. I tried designing this idea with the aims of having a comfortable chair a person could use outdoors, while also being able to blend in with an environment. I desired to have the chair recline for Lombard and back support, while also having a section of the chair overhang for the user's feet to casually rest.



After a few iterations and rough sketches, I believed that I had once again found a suitable design that I could proceed with. I asked my peers around me for advice once more, and they immediately recognised what I was aiming to achieve, with some people referring to my design as a sun chair/lounger. To improve the functional aspects of this design, I included the ability to turn the design from a one person seated chair, into a multi-seated bench, where people can gather during events to sit down on the chair, while individuals on their own can use it in a reclined mode. However, I once again felt uncomfortable with this design despite the greater ergonomic and functional aspects, since this time, I had disregarded the theme and aesthetic elements of the design, and the use of materials felt highly wasteful. Personally, it reminded me of a generic beach chair, except with triple the amount of materials being unnecessarily used. I continued to try and explore the shape of it to make it more engaging by placing a backrest on it, however, it looked too clunky and impractical for a regular person.

At this stage, the timeframe for this project was become narrow, so I needed to choose one of the aforementioned designs that I had made despite their flaws. Although my ideas were not the best, I had an imaginative thought, which was to utilise the seat from the long-chair design, and design around creating benches for public and private use. Initially, I was uncertain as to what bench design is, and how I should approach it within the context of product design. Yet, as I researched various different designs including benches in Melbourne, Sydney, and my local suburb, I realised that many benches neglect exploring the aesthetic elements of the materials, with functionality taking precedent the most, followed my ergonomics, and then aesthetics last.

Evaluation Sheets of the design:

I also realised that people owning private benches were a niche, and were dramatically not as popular compared to the use of public benches (Foderaro, 2013). Using my snake theme once more, the way a snake positions itself in its attack mode could possibly influence the structure and base of the bench as a design piece, acting as an alternative to traditional bench legs. Although this would be a complex shape to create, I believe it showcases the theme of the snake well, while also acting as an adequate distributor of weight for users.

In terms of creating the seat, I had originally intended on using a seat with armrests and a back panel, however, I thought that looked clunky, and would draw away from the snake inspired leg design. I tried other variations of designing the bench, where the snake inspired legs would be positioned on the sides of the design like a conventional chair, which would allow for manufacturing to be a lot easier. However, I decided not to do this, since every other chair I had researched places their legs on the side too, which would force my chair to be a variation of those designs instead of something unique, which is what I had initially intended on making.

The final outcome of this bench design, resulted in me removing the back panel, and creating a slight arc in the seat for comfortability, while also softening the harshness of the timber, which resulted in a design that feels modern, unique, and luxurious. Compared to the initial design concept I had, the transition from a chair into a bench was definitely an unexpected process I did not foresee happening, however, it ultimately turned out the be a project that I was satisfied with.

1) <u>How did this actually happen in practice in the workshop?</u>

Within the workshop, I spent most of my time talking with peers about my ideas, and coming up with concept sketches to suit the design I had imagined. Once I eventually began working on the bench design, I explored pre-existing designs and methods of joinery, which I thought I would test and evaluate for viability and usefulness within the project. One of the first things I tested, was the full-scale mock-up, which gave me an idea of how big the project would need to be, and how everything would feel within an environment. While constructing it, I attempted to make all the curves and shapes, from my initial sketches, however, I soon realised that the structure was not holding up due to how poorly the cardboard handled sharp curves and methods of joining it. I knew immediately that aside from grasping the size of the bench from the prototype, joining pieces of materials together would be a far more important task for me to accomplish.

Entering the workshop with my various sketches, I had a series of tests that I intended to attempt. The first one was identifying the best way to bend metal, as galvanised steel was one of the main options for holding the structures of my chairs and bench designs. I first attempted a kerf bend to create a minor curve, which was then followed by a cold-bar bend, and then finally a reverse kerf bend to create a 180-degree curve. All of these tests were a success at the time, however, I was still deciding how and which one I should use within the designs I had created.

After finally deciding on pursing the bench design, my future tests were oriented around this, with a timber to metal joint using a bolt being one of the most important joinery techniques for the project. Welding would also be a very important way of joining the materials together, while using the appropriate finishes and coatings would prove to be an important aspect to explore.

2) <u>What is the difference between (1) and (2) and its significance? Describe what actually happened and how that was different from what you were expecting:</u>

Initially, I expected all of my joinery methods to working accordingly to how I imagined. To be specific, I had only originally though of cold-bending one piece of metal, and drilling bolts through the timber and wood, until I realised that certain methods were better and needed exploring. One of these methods was the kerfing, as I had not realised that could possibly be a viable option for making sharp bends. Drilling into both metal and timber was another aspect that I needed to explore more, as they required different machines, and the holes had to precisely line up with one another. Welding was one circumstance that I believed to be an easy concept, that would only require me to stick weld a few pieces of steel together. Unfortunately, I was mistaken immensely, as the stick welds were ugly, didn't connect the steel together, and caused myself to accidentally burn by hand. I then attempted MIG welding, which I thought would be easier, but it was also a very difficult challenge for me. After an arduous amount of time, I completed my welds, however, they were not as beautiful and pretty as I had originally imagined.

1) <u>Describe your incremental testing and development approach:</u>

During the testing phase of my project, I divided it into 8 different tests that I would attempt and evaluate in terms of effectiveness towards the design. Originally, it was only meant to be three tests, however, as I continued to improve the design of my bench, I explored certain aspect which I believe would be of value if understood more thoroughly in a real-world environment.

1) Cold bar bending: Cold Bar Bending was one of the first tests and samples that I wanted to try out. Before entering the workshop, I had researched about the best ways to bend metal, and this was one of the most time effective, and easiest ways of bending the material. Although the setup for the equipment did take some time and adjusting, I was able to successfully bend a hollow tube of 30X30mm steel, which gave me the opportunity to proceed with my bench design. Unfortunately, the bending of the bar caused the steel to warp in the centre, which looks unattractive, and may pose structural problems in the future.
2) Stick Welding: Stick welding was the next test I explored, as this would be the easiest method of joinery for connecting bent metal to straight metal. If I were able to successfully create this joint, manufacturing would be a lot easier and manageable, while also being low-cost. Unfortunately, the first few attempts I made at stick welding were rough and ugly, and did not bond to the steel well. It was only after a few more additional tries, that I managed to create some spot welds with the stick welder, however, they were definitely not as pretty as I had imagined. The stick welder also constantly kept blowing holes into the steel, which made it a problem when connecting the pieces together.
3) Timber to Metal Joint: The timber to metal joint was an inevitable sample that I knew I needed to pursue, as it would be the defining joinery technique between the seat and legs of the design. I used a 14mm drill bit on the metal drill press to drill my holes into the hollow steel, which turned out to be a success. I then attempted to drill into the wood, however, the metal drill press was too slow, and so I transferred to drill bit to a wooden drill press, and finished the timber hole there. I then placed a bolt through the wood into the metal, which fit, however, the bolt was poking up too much, so I used a mortising machine to cut out a small square hole inside of the drilled hole, which would help in allowing the bolt to sit proud with the timber. This test allowed me to visualise and realise how the bolt needs to be attached, how the metal and timber are meant to be drilled, and how to finish the joinery method.
4) Metal Kerfing: At this stage of the sample development, creating items from this point onwards were aspects that came to me which required exploring as I continued enhancing and developing my design. Creating the metal kerfs was something I was unfamiliar with, however, I had prior experience kerfing timber, so I had believed it was similar to one another. After my first attempt at kerfing the metal, the cuts I made were not significant enough to pass even 45 degrees. So I spent more time on the bandsaw with greater cuts, however, after kerfing half a piece of steel, the kerf was still barely enough to pass 90 degrees. This is when I experimented with reverse kerf bending, which would allow me to create sharper curves with less kerfs, but at the same time I would be

Evaluation Sheets of the design:

1) sacrificing the structural integrity of the bend. Regardless, these kerfs showed me the importance of exploring this technique within bending metal.
2) Varnish Finish: I had thought about finishing the project in a hard wax oil or shellac, however, since it's an outdoor piece of furniture, I believed experimenting with a varnish would be more beneficial. Using a small amount of varnish, I lathered my timber sample to see whether the process would be easy, whether it would look good, and how it would feel. Ultimately, it was an easy process to apply the varnish, and it looked very nice as it became darker. However, the timber was sticky, which made me believe it wasn't set, but fortunately all I needed to do was rub the excess varnish off with a paper towel, and it became smooth again.
3) Spray Paint Finish: Spray painting was a last-minute experiment to see if it could be a viable alternative to using exposed galvanised steel, as the spray painting would allow for the harsh galvanised steel look to be toned down, making it more suitable in environments such as terraces and parks. The spry painting also adds an extra layer of protection against weathering and the outdoors; however, this test was primarily initiated to assist in making the legs appear more vibrant and engaging within other settings. I do believe the spray does aid the steel in enhancing the shape of the design.
4) MIG Welding: MIG welding was also a last-minute experiment and substation to stick welding, as I felt that I needed to re-explore welding in a greater sense. Using the MIG welder, I connected all of my curved pieces, which resulted in strong firm welds. Unlike the stick welds, the MIG welds connected thoroughly with the material, while also being more user-friendly to use. I unfortunately was unable to create patterns and finishes, however, the functional aspect of the weld was what I was primarily after within this test.
5) Angle-Grinding Finish: Finally, the angle-grinder finish was the last addition made, since it would be instrumental in finishing the welds, and making the overall design look neater. The Angle-grinder allowed me to trim excess welds and metal away, making the design look more consistent and cleaner once it was assembled. Originally, the angle-grinder was not a machine I had intended on using, however, after completing the previous tests, it eventually became a fundamental tool in completing the project.

1) <u>How successful was it at avoiding major pitfalls? Did you have any major pitfalls? Did you foresee any and head them off?</u>

The biggest pitfall or issue that I had within this project was deciding on the appropriate design within the given timeframe. Having cycled through designing a chair, sun lounger, and bench, I spent a lot of the time coming up with ideas and justifying their creation before proceeding with it. This delay caused me to disregard exploring 3-D printing and laser cutting more thoroughly, while also relying on an early fusion360 model that would be used as a 1:5 scaled model. I knew that creating the actual final model wouldn't be too difficult, however, the joinery methods such as welding were events that I did not foresee taking more than 2 hours to learn and retrieve adequate samples of.

2) <u>If you had to replan, how was this done to avoid further problems?</u>

If I had to replan everything over again, I would start my coming up with as many concept ideas as possible within the first week of planning, and then critically evaluate every single one of the designs until I identified the components that I wanted to highlight. I would then come up with a final design before creating my full-scale mock-up, which would then allow me to create a fusion360 CAD model. From this model, I will be able to identify the parts that need joinery methods, and then explore these joinery methods during the workshop hours to grasp what needs to be done on an industrial level. I would also have a prototype model 3D printed to see how it appears scaled, and then a final 3D model that corrects any of the faults or irregularities found within the prototype 3D model. This type of process thinking would help guide my plans along more fluently compared to sporadically working on different sections that overlap and cause confusion with one another.

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