Collapsible Guitar Rack

Contents

1.1 Identification and Exploration of the Need

1.1.1 Possibilities of the Project

There are many problems in the world, with a range of solutions. The Major Design Project (MPD) provides an opportunity to solve one of these problems, however, as there are many problems, it can be difficult to choose one. As a result, brainstorming of possible problems must be done. Figure 1 shows an image of a mind map that a classmate and I produced when brainstorming possible problems to solve.

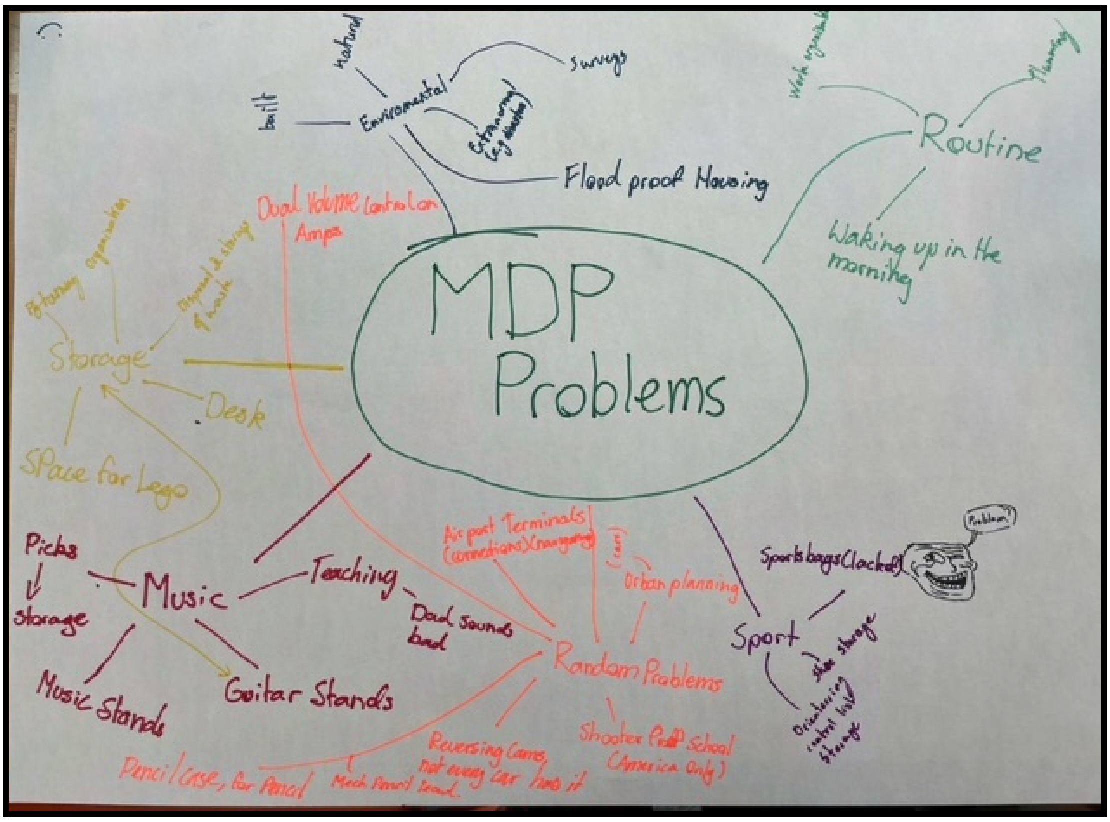


Figure 1: Mind map exploring a plethora of ideas and problems that could be solved from the MDP

Ongoing Evaluations

Having spent some time looking at some of the options in the mind map shown above, I decided that I would go down the music avenue, more specifically guitar storage, since I know that it is a common problem for those in the guitar community, as guitars take up space and it can be difficult to find solutions that don't damage the guitar. Given my knowledge of guitars and previous experiences in Design and Technology I decided to go with creating a new method of storing a range of guitars that is beneficial that solves current problems such as space efficiency

1.1.2 Identification of the Need

When it came to identifying the problem, I found it rather easy as I encounter it every time I pick up a guitar and start to play. I find that the room in which I keep all my instruments gets very cluttered, not from amps, pedals or guitars themselves, but the stands in which I store the guitars (figure 2). The stands are not space efficient and are still obstructing valuable space even when not in use.

Furthermore, all the stands are separate, meaning that when I need to transport the guitars, I have to bring multiple stands with me. A more efficient solution would be being able to take one that can hold all of my guitars and fit into the car without hassle.

As a result, I intend to use this project to solve the issue of guitar storage in the guitar community, as well as my household, by designing a guitar rack that can hold multiple guitars in an efficient manner, whilst simultaneously being able to fold into a more convenient size for ease of transport. This will be done by looking at the flaws in existing designs and researching various methods of addressing said flaws, and with the aim of resulting in a successful product.

Figure 2: The music room, where space is at a premium

Identifying the Target Market

The target market for this project is the guitar community (anyone who owns a guitar and consequently needs to store it). Anyone who is committed to guitars will have picked up several, and thus will demand some form of storage. The product is tailored to those who have a sizable collection who also need to bring multiple guitars to concerts/rehearsals. Given the nature of concerts and the different sounds provided by different guitars, many guitars can be needed for a single show. However,for small bands that do not have much money, a stand that can fold down flat would be beneficial and cost effective.

Justifying the Need

This project is justified as a better solution to guitar storage is needed. Right now there is no way of holding numerous guitars on one rack that is also collapsable for ease of transport. This is needed as from what I have experienced, there is an inconvenience in having to ferry 4+ guitar stands to the car, and load them in all individually, whereas with one stand, all that would be required is to collapse the stand, and make one singular trip to the car.

Design Brief

This project is aimed at producing a guitar stand that can hold multiple guitars of varying shapes and sizes, whilst also being able to fold flat for ease of transport in order to reduce the amount of space taken up by the stand. This product is being designed for guitarists who have multiple guitars and might need to take a stand to concerts capable of storing these guitars which could be of multiple shapes and sizes.

The goals for this project are to achieve a successful solution to the problem of guitar storage, whilst also meeting the guidelines set by the limitations of the task.Furthermore, being made of recyclable materials will ensure that if the product fails, it can be repurposed. There are several parameters that this product must meet as well. The product must be safe to use, meet the $200 budget and be completed by the due date of the task, the 24th of August 2023.

Ongoing Evaluations: The product I have set out to achieve is valid. The justification of the need and the target market all align with the problem that I have outlined and thus has set up the perfect opportunity for a point of difference to designs that may already be on the market.

Opportunity for Innovation

It cannot be disputed that there are already many guitar racks on the market that serve the purpose that is needed. However, one major problem is that there are not any racks that can be portable whilst also accommodating various shapes of guitars. Having done a brief scan of guitar racks available for sale from music stores, there was only one rack that I found that can accommodate flying V guitars, as shown in figure 3.

This stand is specifically designed to store multiple flying V guitars, however there is the problem of stand A, not being collapsible and B, not being able to store normal guitars. This is a common problem with all the guitar stands and racks that I see on the market, where none of them can hold multiple guitars, while simultaneously being easily transported or holding various types of guitars all in one. Whilst there are many guitar stands that do many of the listed requirements, there are none that can do both, and I believe this boils down to a simple problem, that being, how the stand holds the guitar.

Figure 3: Flying V guitar stand from Allwoodstands.com (Allwood Stands, n.d.)

There are predominantly two types of guitar stands. There are those that have a cradle near the bottom to hold the guitar body (*figure 5)*, and there are those that have a special clamp near the top to hold the guitar at the top of the headstock and let it hang (*figure 8*). Both stand types have their advantages and disadvantages, however the ones that are relevant to this problem are how they hold the flying V body shape(*refer to figure 6*). Both stands can hold normal guitars fine, as the cradle is designed for normal body guitars, and the clamp can hold any guitar as all the headstocks have a similar shape. However, the cradle design cannot hold a flying V, as the points of the body are generally too long and end up touching the floor (*refer to figure 6*), which is not recommended for storage as the weight ends up going through the guitar and not the stand. The point of difference in this design is that the stand will have a method of holding the guitar that can cope with both body types, as well as be collapsable.

1.1.3 Exploration of the Need: Initial Research

Figure 4 is a PMI table that evaluates the existing guitar racks.

Figure 4: PMI table of existing designs

Guitar Rack	Positive	Negative	Interesting
 *Image Credit: allwoodstands.com*	This guitar rack is able to hold 3 guitars, and there is another variant that holds 5. The rack is capable of holding flying V shapes. In addition, this particular stand seems to be rather space efficient.	This rack can only hold V shapes, not any other normal guitars, and the stand is not collapsable.	The system of support uses 3 tubes that fit the gap in between the two parts of the flying V shape.
 *Image Credit: gatorcases.com*	This rack can hold up to 4 guitars and is portable, as it can collapse down into a small suitcase.	Whilst this guitar rack can hold regular guitars, it is unable to hold flying Vs. Furthermore, the nature of the stand means that there would be loose parts within the case, and the complex nature of the rack means that it might be more difficult to produce than others.	I find it rather interesting how it folds into a suitcase, as it could provide an opportunity for a handle to be attached for ease of transport.
 *Image Credit: rollingstone.com*	This rack is lightweight and portable, being able to collapse down into something much smaller, and it can hold up to 7 guitars.	As with other stands, there is no ability to store both normal and flying V guitars on this rack.	The simple nature of this rack means it could potentially be made out of metal tubing, making the design cheap and more environmentally friendly.

 *Image Credit: megamusiconline. com.au*	This stand has a sleek aesthetic look, and can hold 5 guitars. Furthermore, there is a very simple structure, making the rack easy to produce.	As with all the other stands, the rack is incapable of holding both regular and flying V guitars.	Whilst there seemingly isn't a possibility of folding the rack, the design seems like it could very easily be changed to accommodate a hinge. Furthermore I can see myself using the simple angle joint in my project, as I really like the look of the slanted poles.
 *Image Credit: mannys.com.au*	This stand uses a simple A frame and has lots of foam padding on all the surfaces that come into contact with the guitar, however, whilst most stands and racks have this, this one also has some extra padding in the event of unexpected movement near the base of the rack.	The rack can only hold 3 guitars and is incapable of holding any unique guitar shapes such as a flying V. Furthermore, the rack cannot fold down to a smaller position.	The use of discs at the base of the stands to stop the guitars sliding around is interesting, as it provides a buffer between guitars of varying widths.

Evaluation of Current Stands in my Possession

The evaluation of existing guitar racks shows that there is no rack out there that can fulfil my needs for a folding, shape tolerant guitar rack. Therefore a system of storing both types of guitars must be designed, and to allow that to happen, research is required. To do this, I decided that I should investigate suitable methods of holding various shapes of guitars without needing to adjust anything to keep it as simple as possible. I found that the method of most of my current stands (the cradle method) works well for normal guitars, but is simply too low for the flying V to sit safely in a suitable manner, seen in figure 4. However if the cradle was raised higher by any amount, the cradle would be able to support the flying V shape by resting the inside of the tails as seen in figure 5.

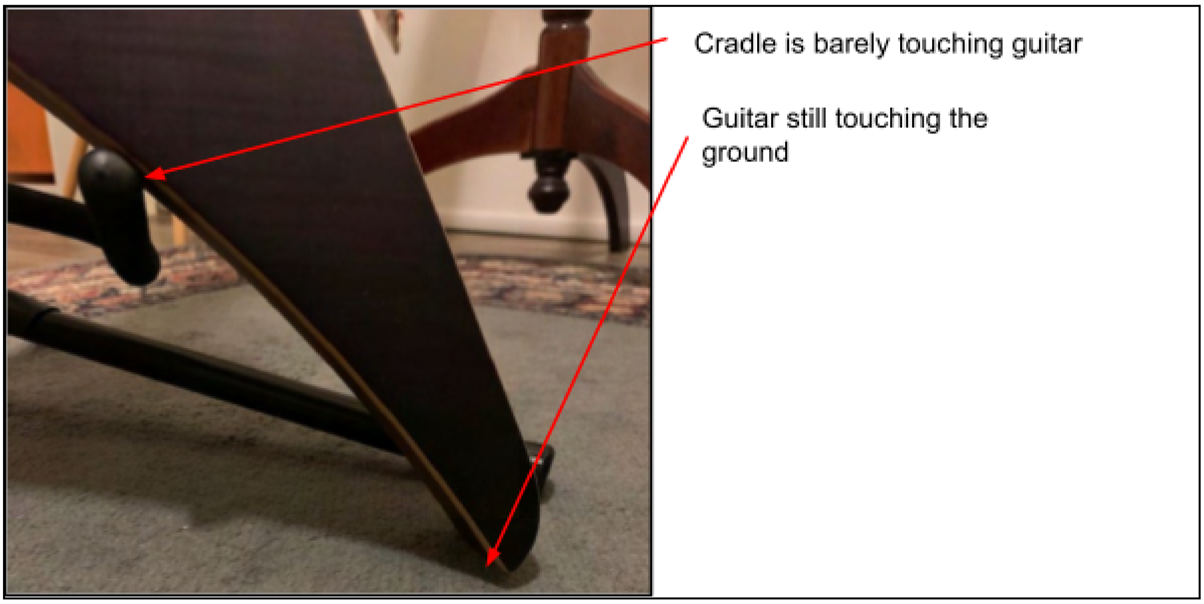


Figure 5: Cradle type guitar rack

Figure 6: The cradle can carry the flying V with a height adjustment. Note that in this image I am lifting the whole stand off the ground.

The second form of storage that requires no adjustment is the hanging clamp method. This can hold any form of guitar as the necks are all relatively similar in figure 6. As this can hold any type of guitar, the only thing that needs to be considered is the height of the clamp. Figure 7 shows my flying V from on the clamp stand, and it is only 3 cm from the ground. If the clamp is kept high enough, then a rack consisting of the clamps would be possible.

The clamp method also has a failsafe in place, with mechanical arms that swing up to keep the neck of the guitar from sliding out when the guitar is placed on the clamp. This mechanism is shown in figure 9. The clamp would allow a more secure method of storing the guitar, however the mechanisms behind it can be complex to design and more costly than other methods. However, there is another version of the clamp that does not have the mechanical arms, and as result, just has the guitar headstock resting on a similar structure.

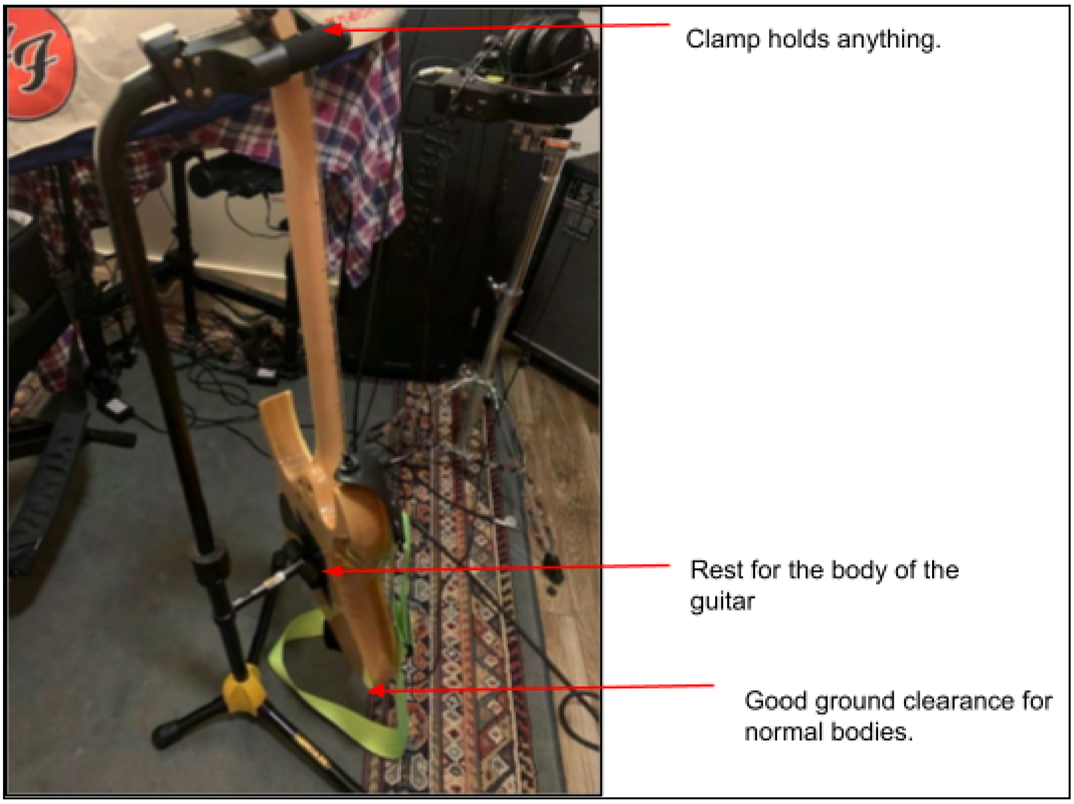


Figure 7: Clamp style rack holding a normal guitar

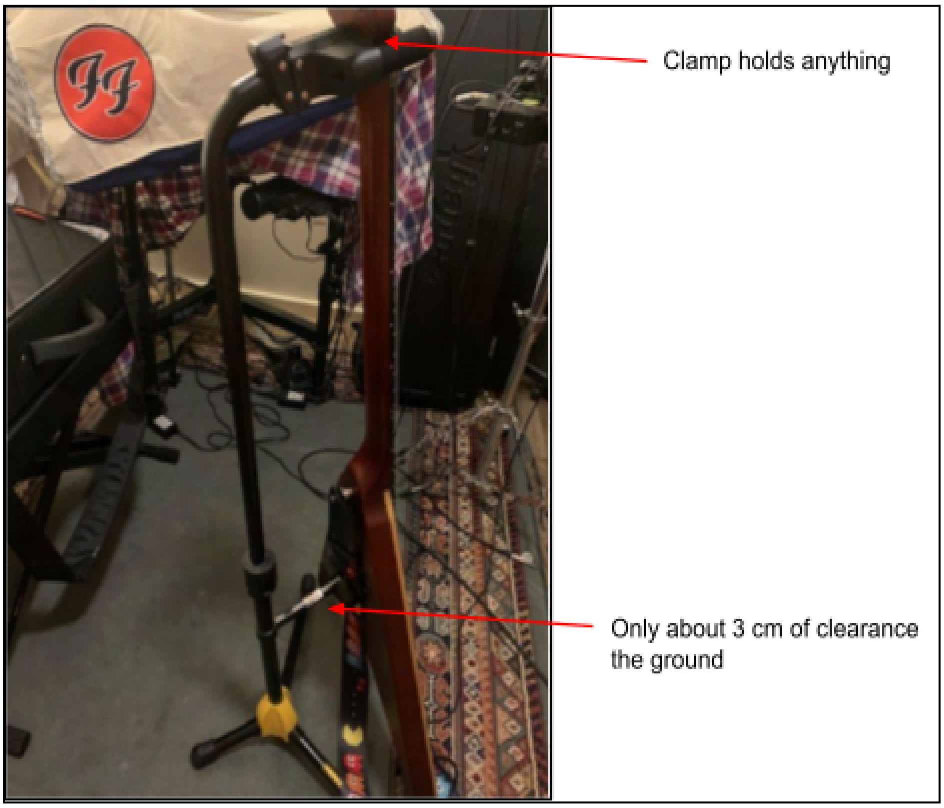


Figure 8: Flying V on the clamp stand. The clamp can still hold the guitar headstock, but there is not much space between the bottom of the guitar and the floor.

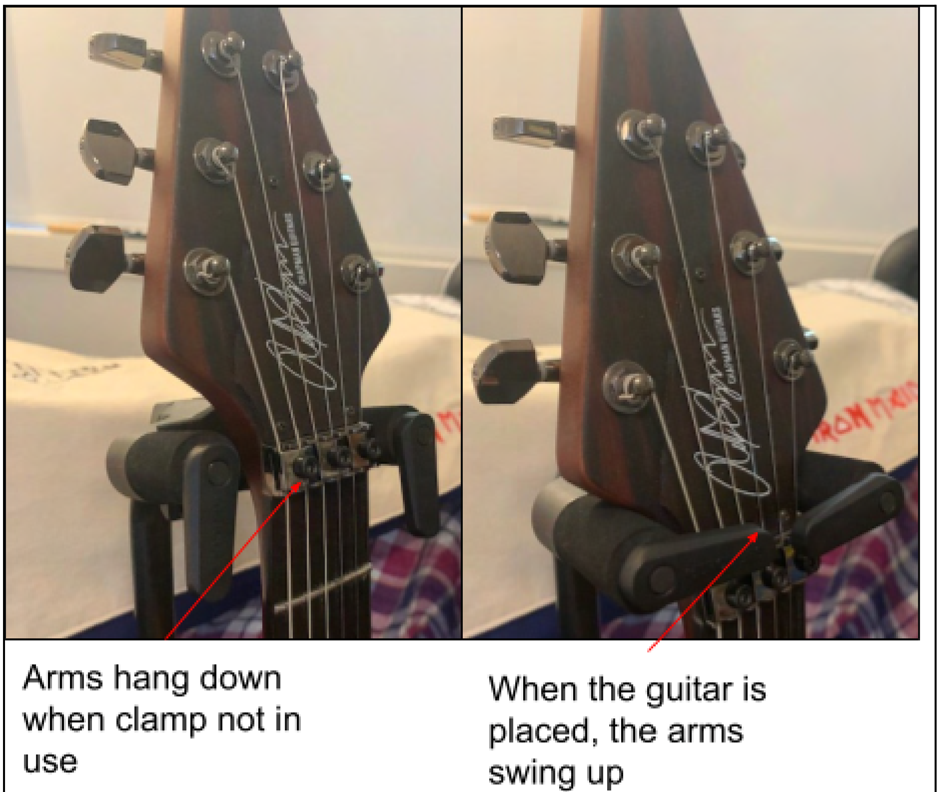


Figure 9: Mechanical Clamp method, the weight of the guitar causes the clamp mechanism to lower, causing the mechanism inside to swing the arms up.

Furthermore, if the guitars are to be stored facing each other, rather than outward, the slots for the guitars will need to be spaced out enough because. After measuring the depth of the body on all my guitars, I found that the flying V was 4cm, the Ibanez, Gibson and Explorer were all 4.5cm, and the acoustic was 9.5cm and as such will make sure that the rack has 9cm of space in between the 5cm wide slots. Furthermore, the minimum height of a mechanism to support the guitar from the base must be 15 cm to allow a safe level of clearance from the floor and to accommodate even larger guitars.

Ongoing Evaluation: Having conducted research on both my current stands and others on the market it was clear that there is a genuine gap in the market for a stand that is designed to hold multiple types of guitar whilst also collapsing. There are stands that can do one or the other but not both. In addition, evaluation of my current stands has solved some of the issues on how to physically hold the guitars which will make designing the stand easier.

Surveying the Community

Below are the results of the survey I sent out to anyone who has experience playing guitars, each with a range of experience with different types of guitars. The idea behind the survey is that it is a good method of primary research that can give me valuable data to see if this product I am designing would help people other than me, expanding the perspectives of input in this product. Whilst the product I make will still be tailored to myself, the result can let me know if I can make any special accommodations for other people as a proof of concept.

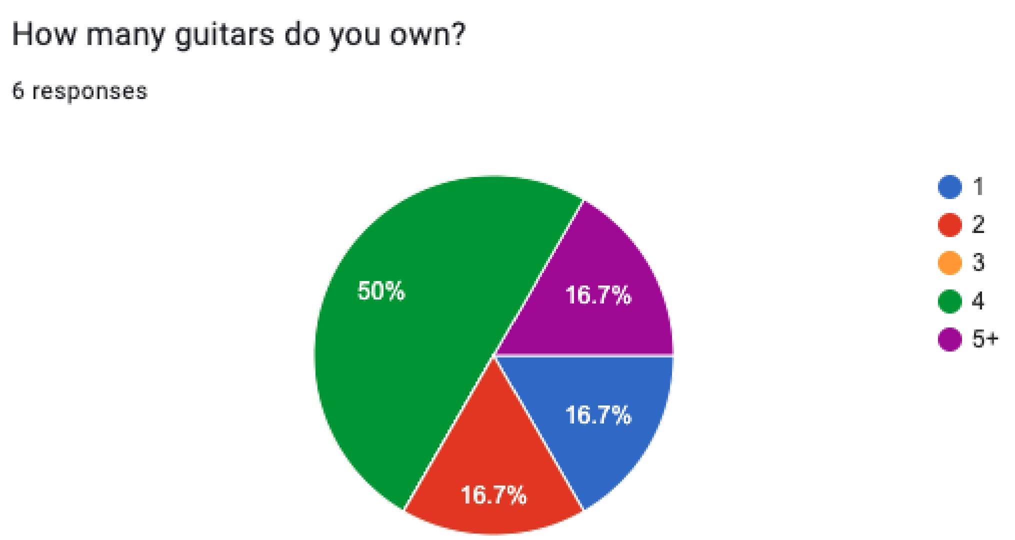


Figure 10: Pie chart showing how many guitars people own.

How often do you use your guitar(s) each week?

6 responses

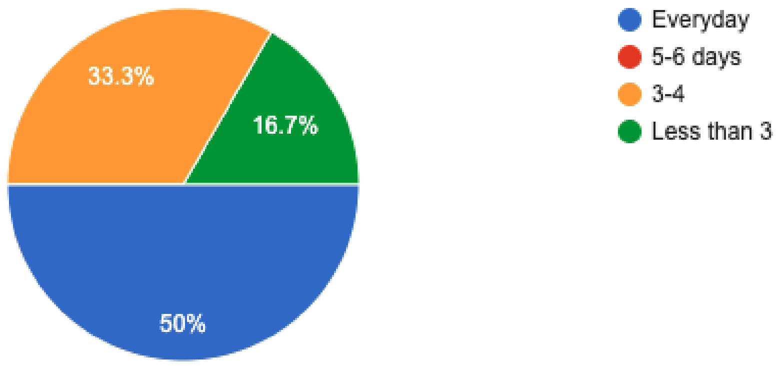


Figure 11: Pie chart showing how often people use their guitars.

Consequently, how do you store your guitar(s)?

6 responses

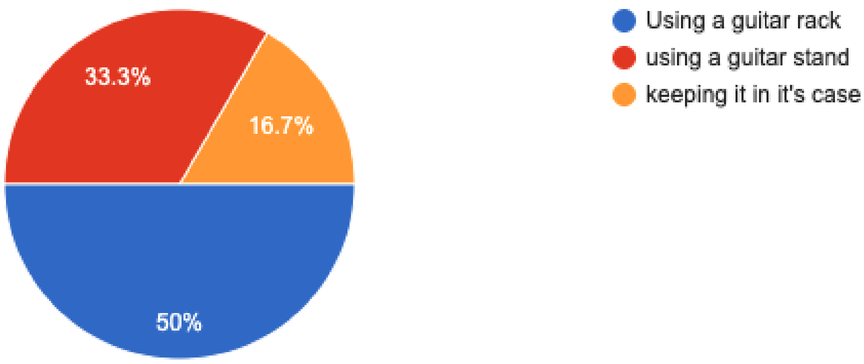


Figure 12: Pie chart showing storage methods people use for their guitars.

What type(s) of guitar do you own?

6 responses

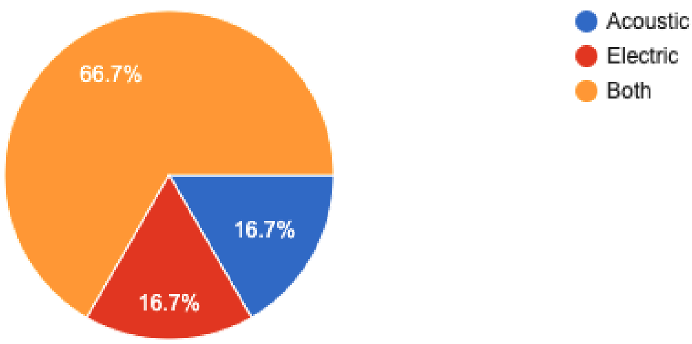


Figure 13: Pie chart showing the types of guitars people own.

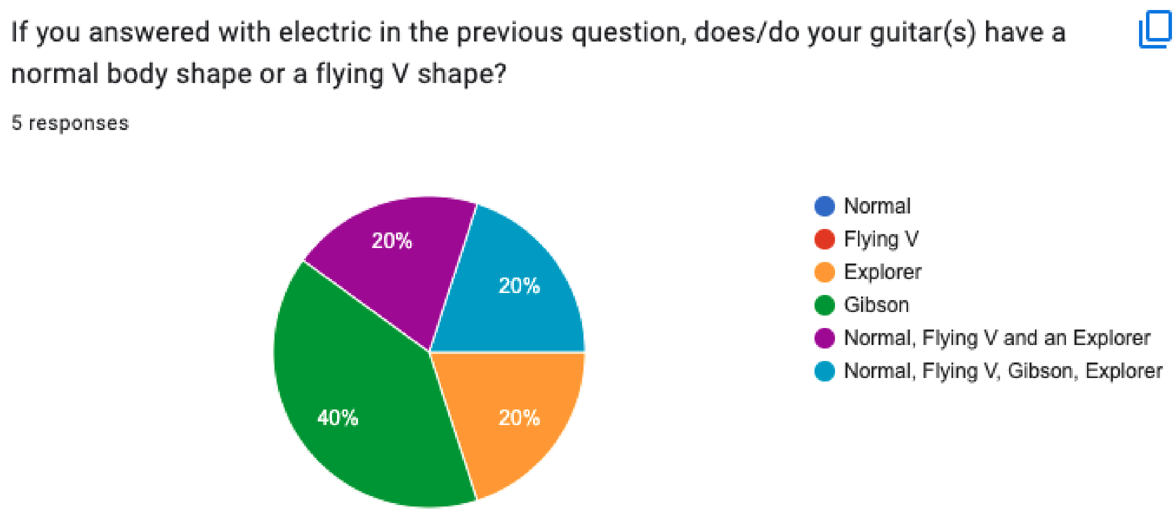


Figure 14: Pie chart showing the prevalence of various body types.

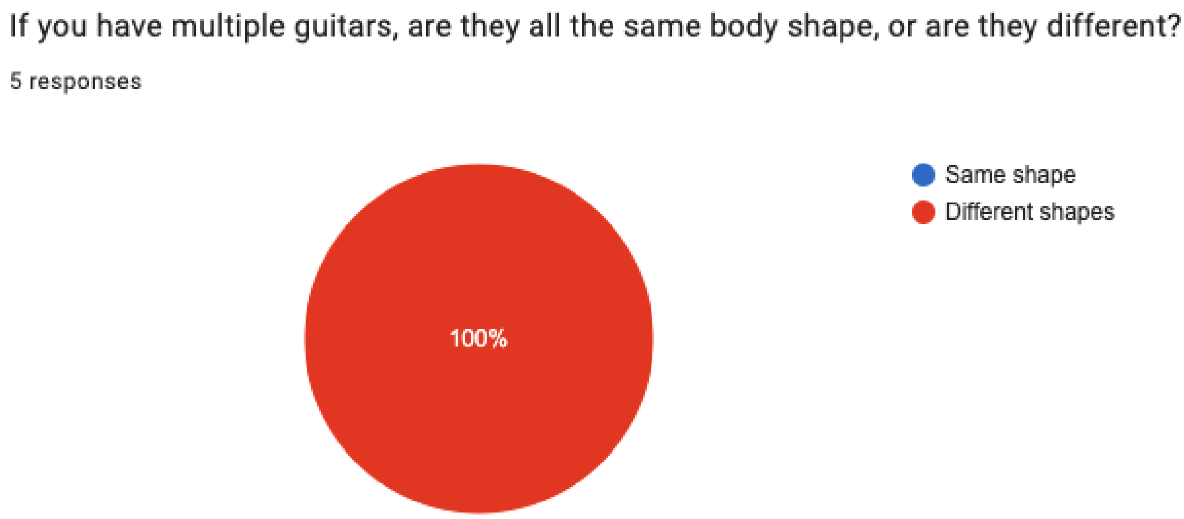


Figure 15: Pie chart showing if people have variety in their guitar shapes.

If you own a Flying V or Explorer, do you have problems storing it? (e.g. I need a special type of stand)

5 responses

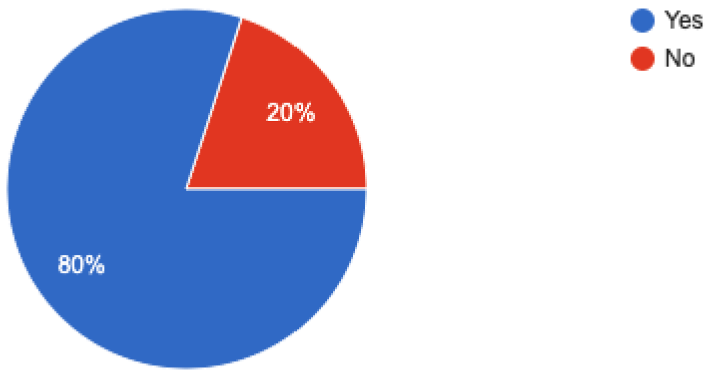


Figure 16: Pie chart showing the prevalence of problems as a result of body shape.

Ongoing Evaluations: The main takeaways from this survey is that over 60% of the people surveyed have over 4 guitars, with everyone being surveyed that had more than one guitar owning guitars of different shapes, meaning that a rack to accommodate different shapes and sizes would be justified. Furthermore, there is a large level of diversity in the shapes of the guitars, and 80% of the participants in the survey who own a flying V or explorer have difficulty storing it.

Within the survey there were some short answer questions, which provided some valuable data on user experience with guitar stands to take into consideration with designing a guitar rack. Whilst the product is for personal use, some of these problems are universal irrespective of the user such as needing more space.

- Along with the survey, I provided some short answer questions:If you own multiple guitars, is moving around multiple stands when going to rehearsal a problem?

no as i only need 1 guitar for a preformance

Only bring one and or leave my seconds guitar in the case

Only bring 1, but a method to bring all would be fantastic

I tend to only bring two guitars, but often they are different shapes so multiple stands are required. This is okay as i have a large car, but it is troblesome for carrying the instruments into venues

Yes, when moving to practice, I need to bring all 4 guitars, and subsequently 4 stands.

- Or do you only bring 1 guitar to rehearsal and thus only need 1 stand? Below are some of the top responses:
- Would you say your method of storage is suitable for you? (e.g. I need more space, or no I'm fine as it is)

Below are some of the top responses:

yes as i have one guitar out that i keep on a stand to play whenever and then one in the case for guitar performances and lessons to transport

I need more space because I have an explorer so it's a weird shape

Easier access would be nice, and maybe a way to prevent dust collection

it is quite unattractive and takes up a lot of space in my room.

I have 4 stands, takes up space.

Ongoing Evaluations: With this survey in mind, the ability to store multiple guitar shapes in an efficient manner seems to be a genuine need. In the survey, several people have a need for more space and more storage for unique guitar shapes. Furthermore, there were some unique responses in the survey, such as a need for a more aesthetically pleasing rack, which I would not mind, however it is not required for the product to be successful. The key takeaway is that there is a genuine need for a stand that can hold multiple shapes and be easy to transport.

Whilst there were not as many responses to the survey as I had hoped, there were still enough answers to show that people do have problems with guitar storage which is enough to guide my project development. It also showed the importance of being able to store odd shaped guitars, as one respondent stated that their explorer is difficult to store and consequently produces problems for them.

1.2 Areas of Investigation

1.2.1 Areas to be Considered

Figure 17: Table detailing various areas that need to be considered

Areas to Investigate	How will it Benefit my MDP	Research Plan
Existing Products	Knowing the differences in existing products designed to solve this issue will help as it will allow me to focus on the aspects that are not addressed in existing products.	In order to find out this information, I will look at existing designs and create a PMI table to assess the pros and cons of each design.
Safety	Safety is a crucial part of almost any product, and not just for the user. The guitars will also need to be kept safe, meaning if I can ensure that the product is safe for all stakeholders, it will result in a better outcome.	I will find out how to make things safe by researching the sizes of guitars to ensure there is adequate room to store them safely, looking at materials to find soft and durable padding, and looking at various manufacturing techniques to ensure that the assembled product is safe.
Design Factors	It is important to consider the design factors involved and concentrate on making sure that the most important ones are evident in the design, as without them the design serves no purpose.	I will create a success criteria that the design must meet, and constantly evaluate the effectiveness of the design and the prototypes produced.
Function	Without function, the product is useless. Having a functioning, easy to use guitar stand that stores all types of guitars will be beneficial to my MDP as it is the main goal of the project.	I will look at various types of materials, storage methods and experiment with folding legs to ensure that the stand can function properly.
Target Market	Knowing the target market will allow me to tailor the product to them. If I can know important details relevant to the project, I can make the guitar stand more appealing and thus more useful to the target market.	I will gather information via a survey to find out things such as how many guitars people own, and how many different types of guitar shapes people own.

1.3 for Evaluating Success

Figure 18: Criteria for success

Criteria	Why is it Essential	Impact if not Achieved	Minimum Standard
The rack must be able to hold 5 or more guitars	This is essential as at this current time I own 4 guitars that require stands to be stored, and I would like room for others to ensure that any future purchases are able to be accommodated.	If not achieved, more space would be taken up by guitars that are unable to fit on the rack, and thus the purpose of this space saving solution would be nullified.	I will accept the stand being able to hold 4 guitars, as I currently own 4 guitars, meaning the stand can at least act as proof of concept.
The rack must be capable of folding down into a smaller position.	I am often packing all my stands to go to band practice, meaning that the rack must be able to fold up to allow ease of transport.	If this is not achieved, it would mean a large rack would be required to fit in the car, and at that point it's easier having individual stands.	The guitar rack must be able to at least fold into a smaller position that can fit in the gap between seats in my car.
The guitar rack must be able to hold multiple shapes of guitars	My father and I have various shapes of guitars which would in an ideal world be able to fit on the rack. The rack must be able to accommodate normal guitars, flying Vs and explorers.	If this is not achieved then there would be no point of difference in this design when compared to other designs on the market.	The minimum standard that I will accept would be the rack being able to fit several guitars of the same shape, or at least flying Vs and normal guitars.
Environmental friendliness	The rack must be environmentally friendly so that if all else fails the scraps can be recycled, or if the product is successful, then when it reaches the end of its lifespan, it can be recycled.	If this is not achieved, then if the product fails, it will be a waste of materials, which is not environmentally friendly.	The minimum standard for this criteria would be if the rack can be repurposed for something else useful, or the materials at least be eco friendly.

Ongoing Evaluations: Whilst I still have no clue on how I will actually build this stand aside from a few methods of physically holding a guitar, the development of a criteria for success and areas of investigation will allow me to make a start on building this product. However, it still remains unclear as to whether or not I have left something out of consideration such as ergonomics or ease of use.

2.1 Product Development and Realisation

With research justifying the production of this rack, developing ideas is the next phase in the design process. This includes small sketches conceptualising and visualising ideas that come to mind when thinking of solutions. These ideas will be refined into the 3 main solutions used to address the problem. Below are several pages of sketches that I have made to help think of a solution to the issue of storing multiple types of guitars.

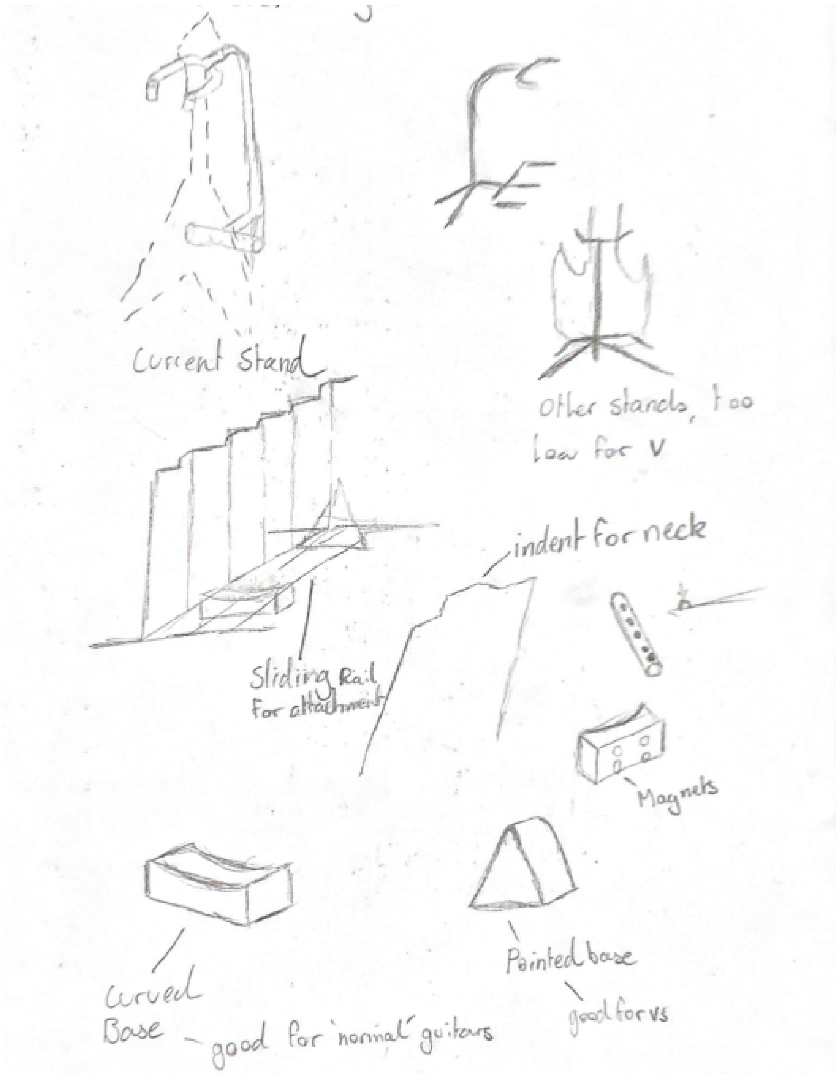


Figure 19: Annotated sketches of some ideas for guitar stands.

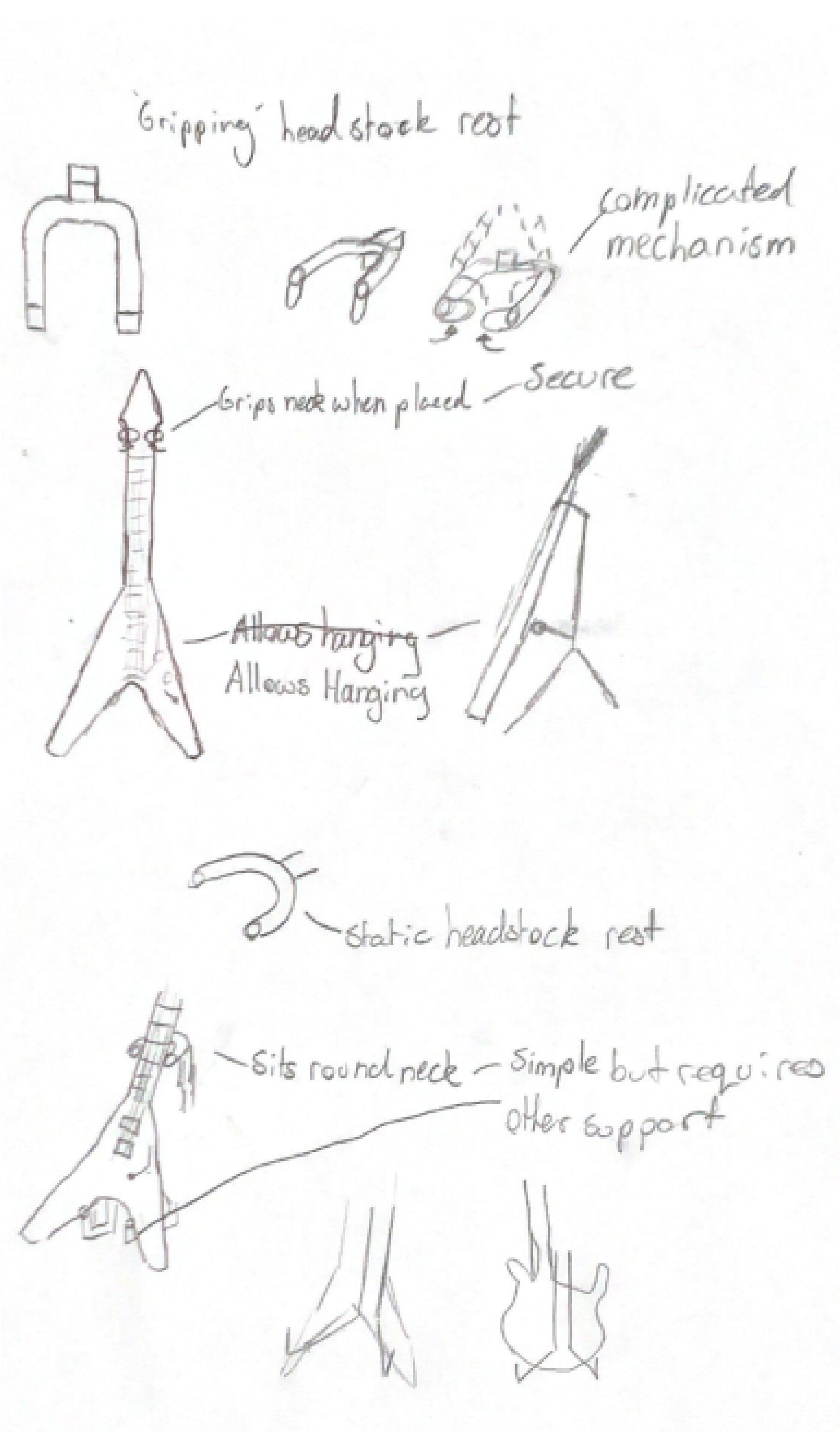


Figure 20: Further annotated sketches.

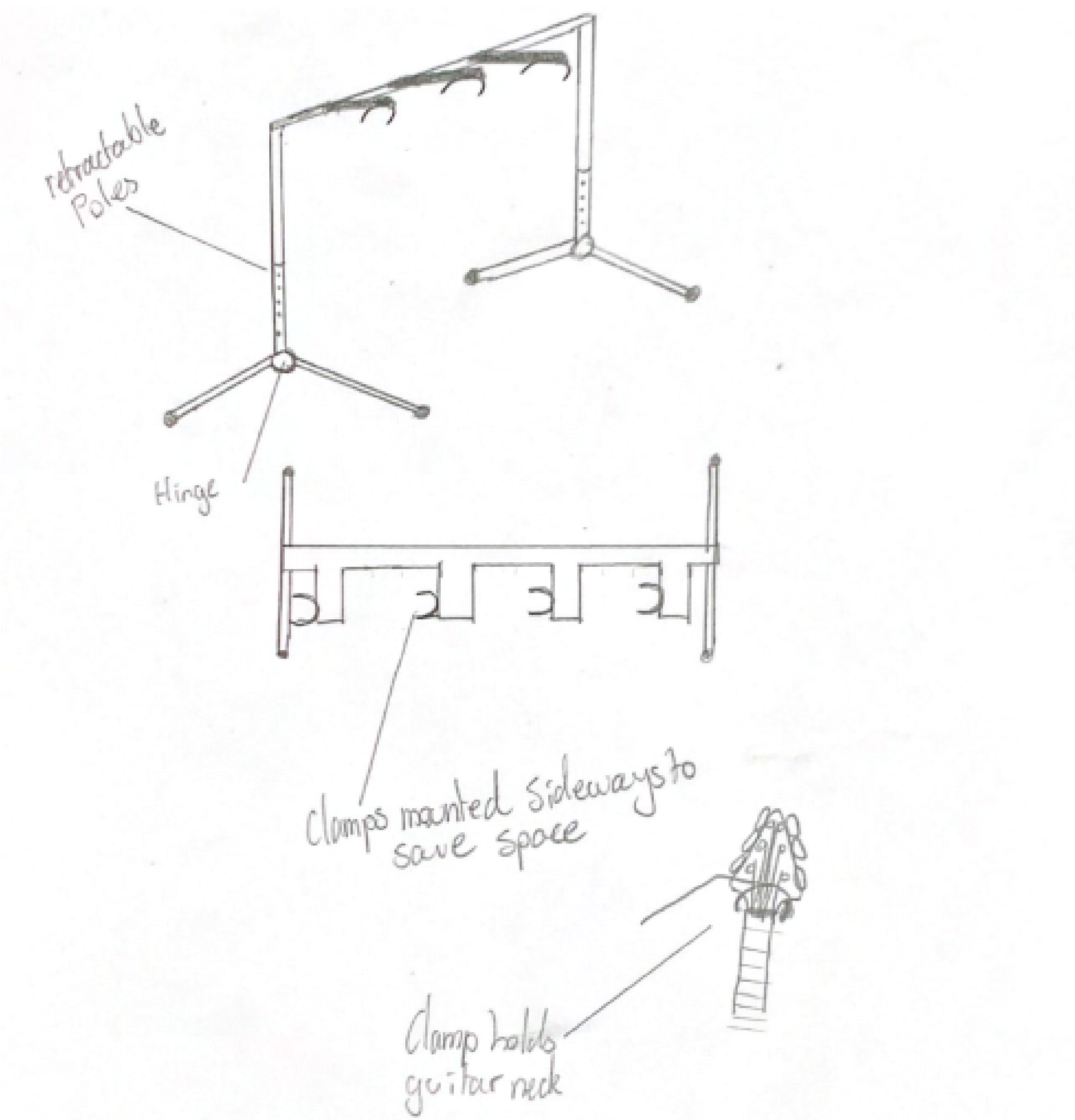


Figure 21: Further annotated sketches.

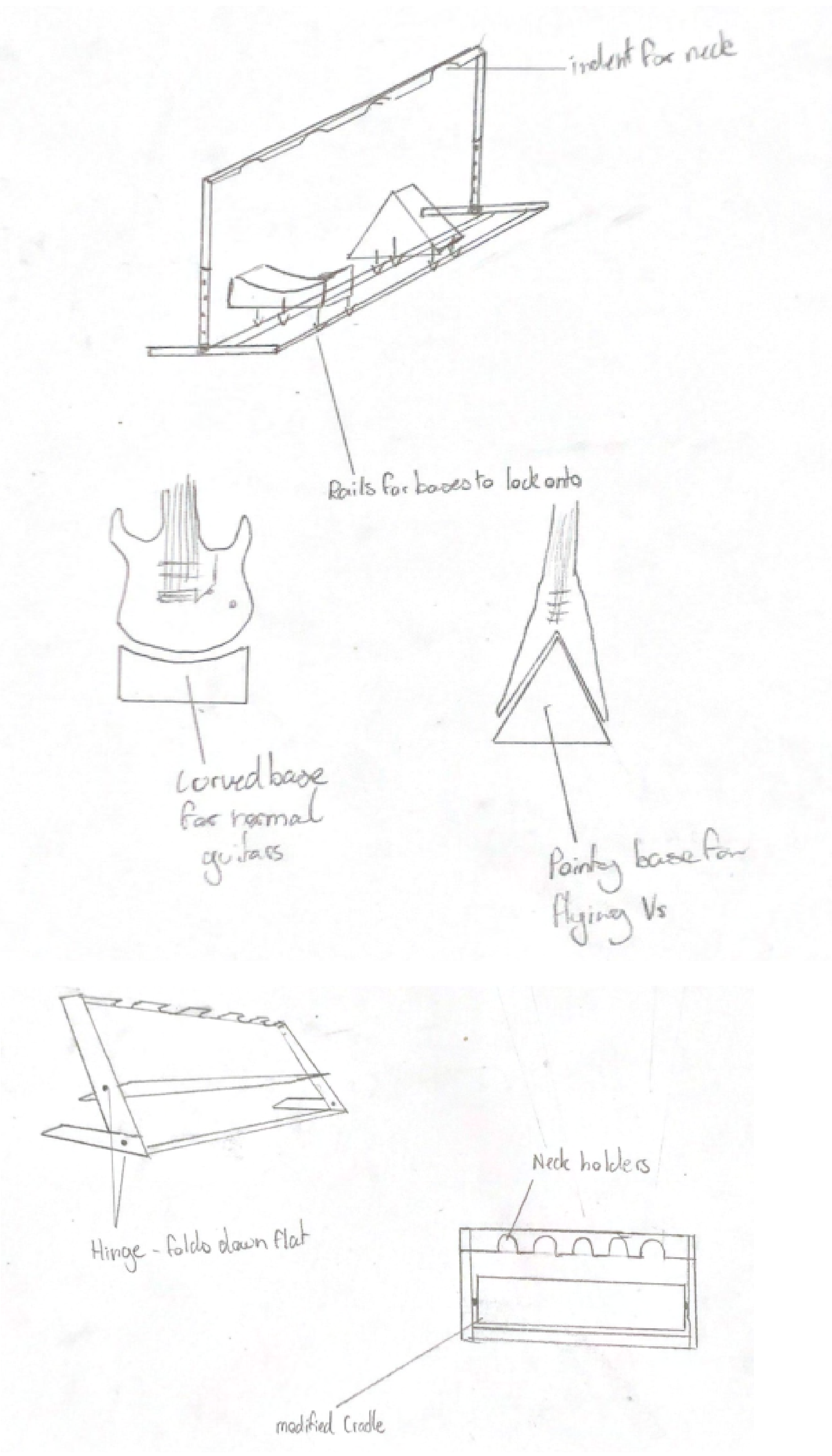


Figure 22: Further annotated sketches

The above sketches represent the basic concepts and the process I went through to come to the 3 solutions detailed in the next section. The first 2 sketches were looking at existing problems and putting thoughts on paper about methods of storage. The next 3 sketches were of possible solutions for the problems.

Below are some cardboard prototypes of the 3 concept solutions to be used as a visual aid when making the 3D CAD models for the refined solutions.

Figure 23: images of cardboard prototype

Ongoing Evaluations: With proper visualisations leading to 3 distinct versions of the stand, I can now focus these ideas on more refined models, however I will need to tame the CAD software inorder to produce models of good quality.

2.1.1 Solution 1

This solution is a stand that has a set of rails at the bottom for detachable bases to clip onto. The bases are designed to hold both flying Vs and normal shaped guitars. There are 5 slots and the guitar neck rests on the arm that extends out at the top. The rack would be able to fold down into a position for easy storage. Below is the 3D CAD model of the refined cardboard model shown in the previous section.

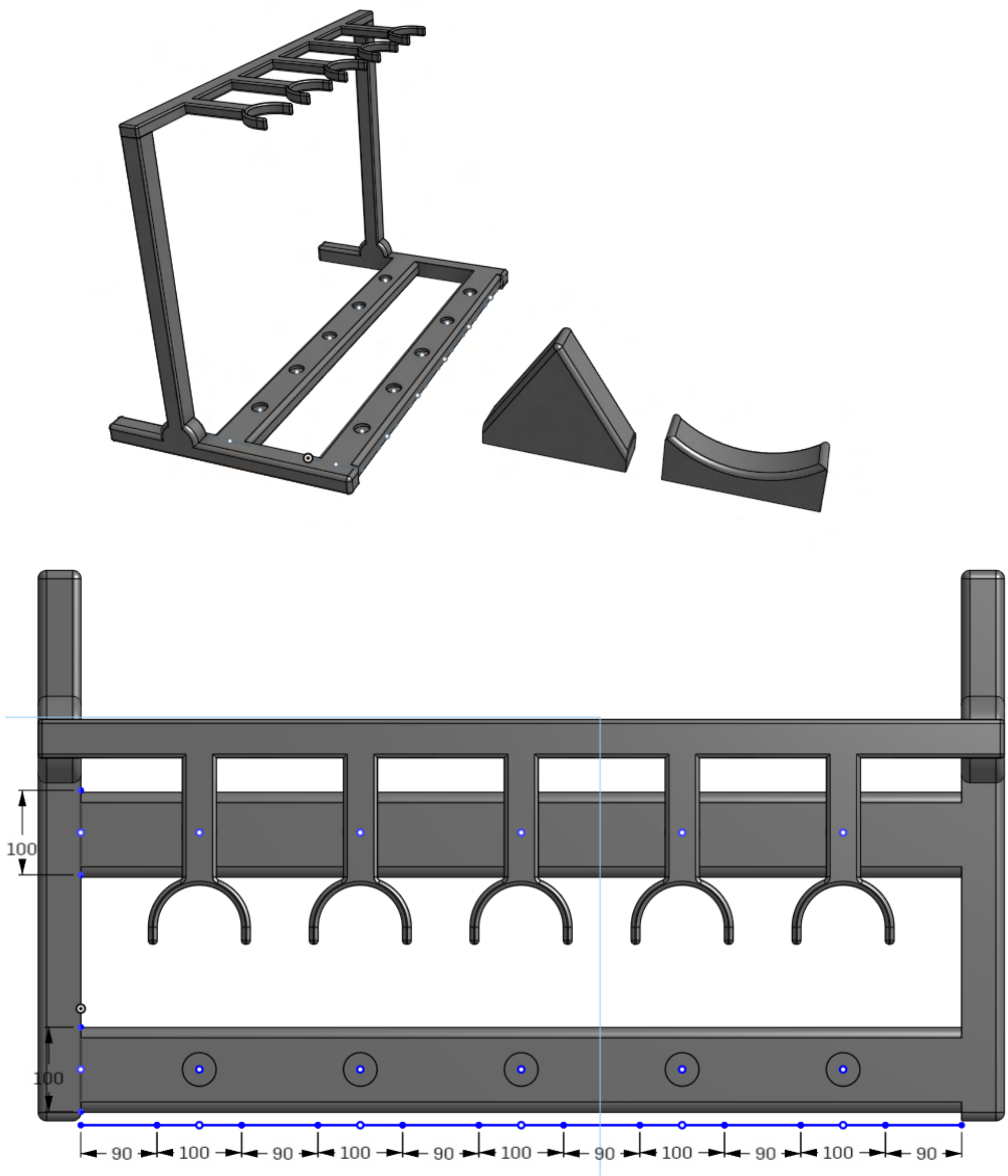


Figure 24: Images of 1st solution

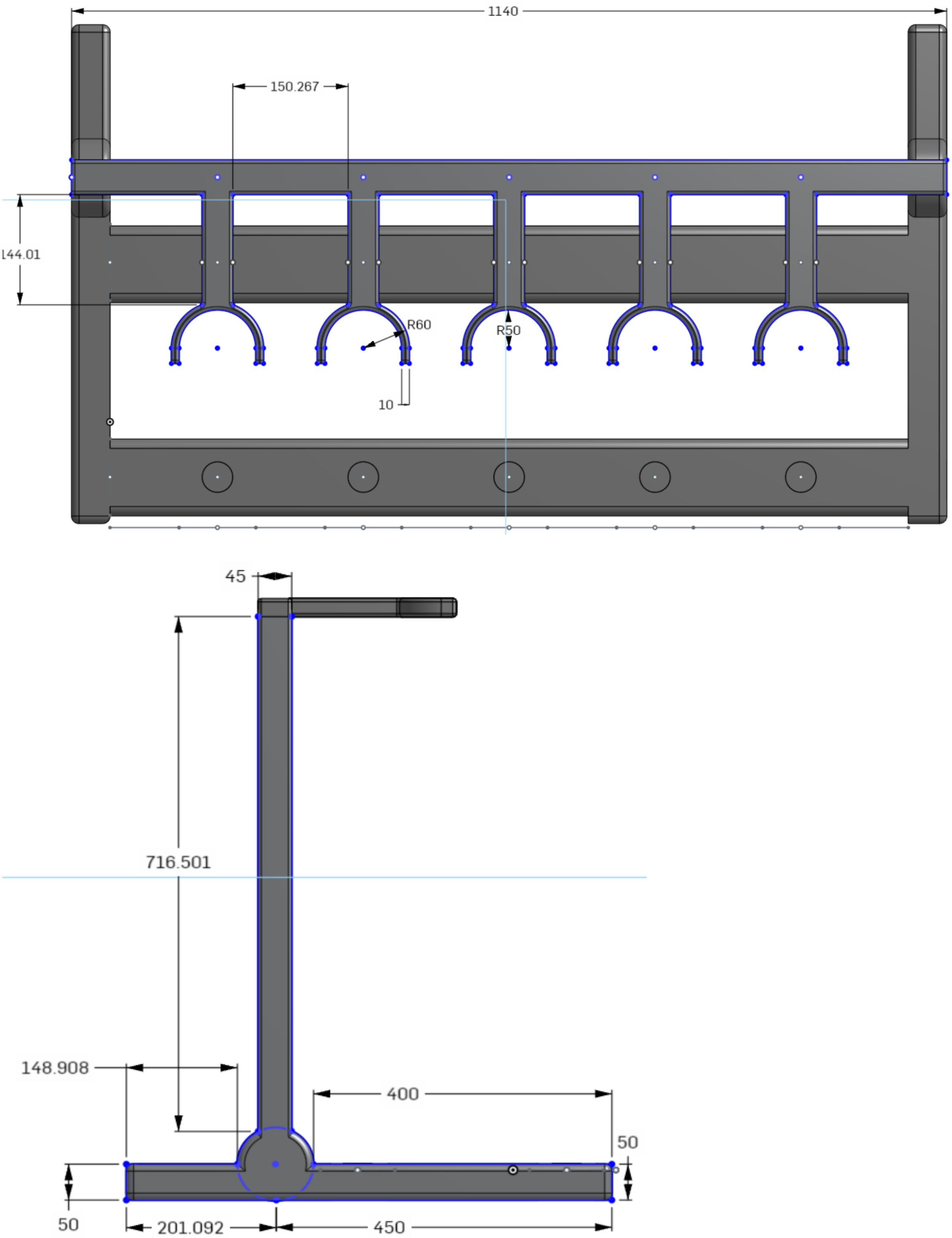


Figure 25: Further images of solution 1

2.1.2 Solution 2

This solution utilises a sleek frame to hold a modified version of the cradle on some of the stands I have at home. This then has the guitar necks rest in the indents at the top of the guitar. The frame would be able to fold at the joint at the base to fold down into a flat position. The modified cradle should in theory be able to support both flying Vs and normal guitars, as well as explorers.

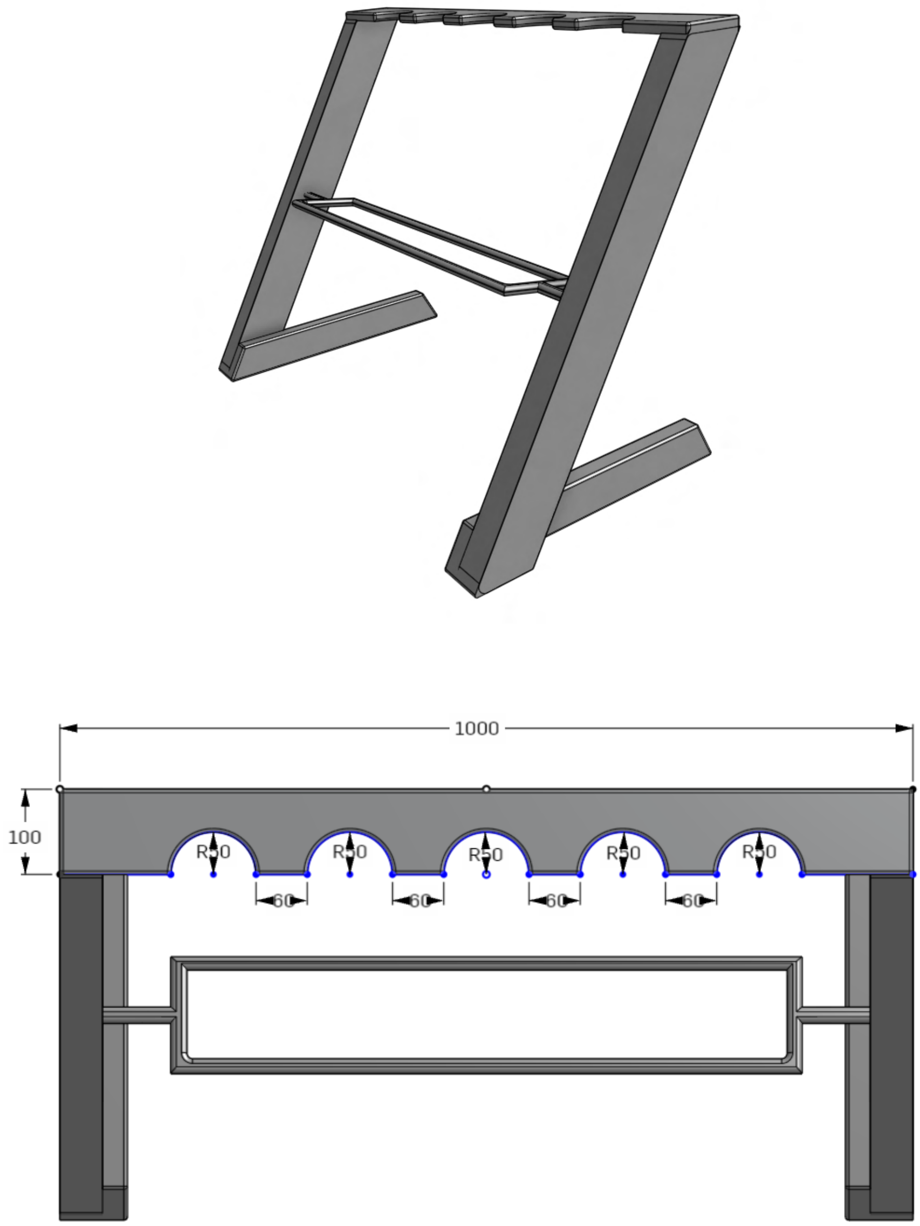


Figure 26: Images of solution 2

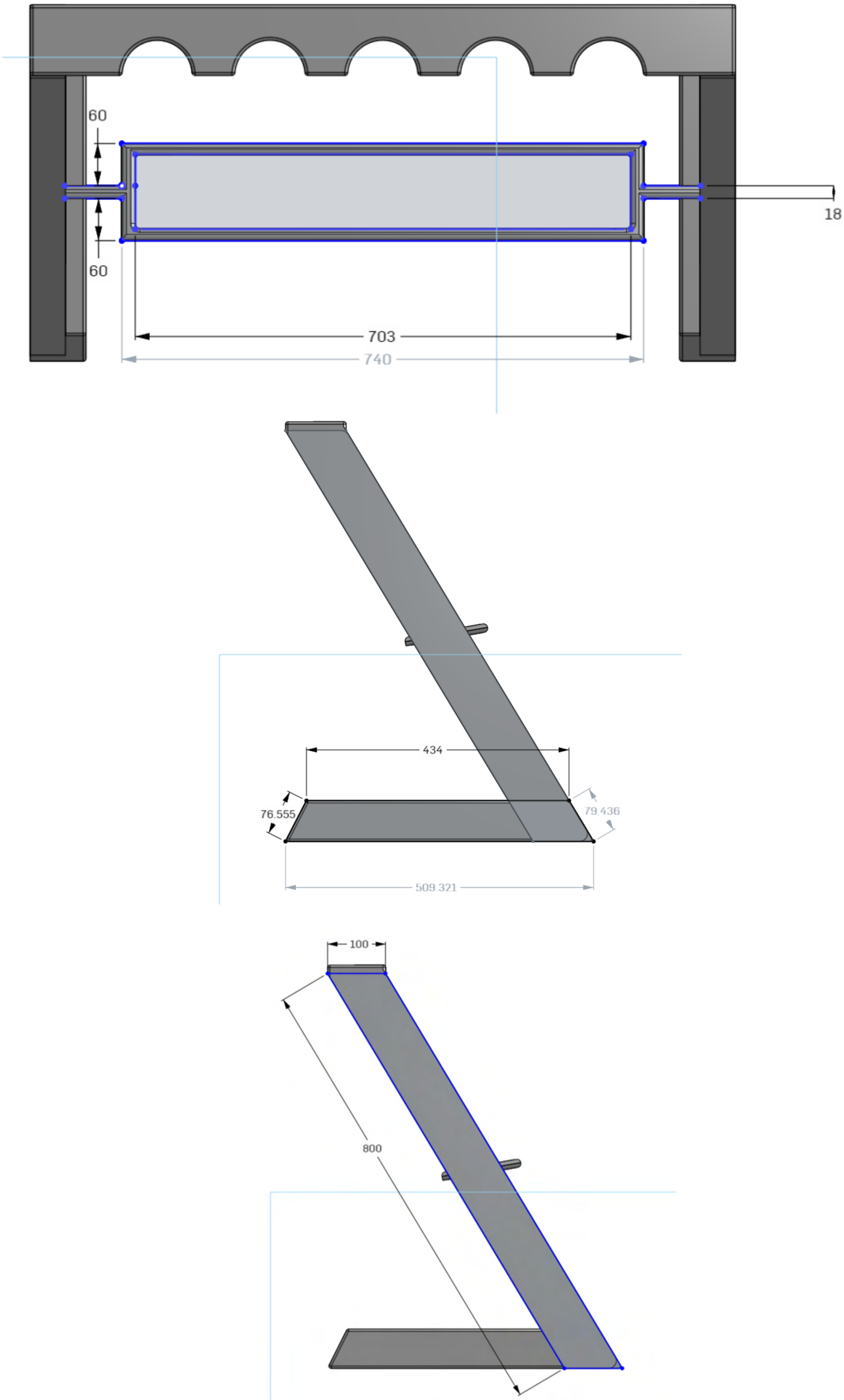


Figure 27: More images of solution 2

2.1.3 Solution 3

This solution is similar to the first one in the sense that it has a similar shape, however unlike the previous two solutions, this one functions by having the guitars hang from the headstock, rather than be supported by the base of the guitar. This rack would be similar to the first solution in which the legs can fold down into a flat shape.

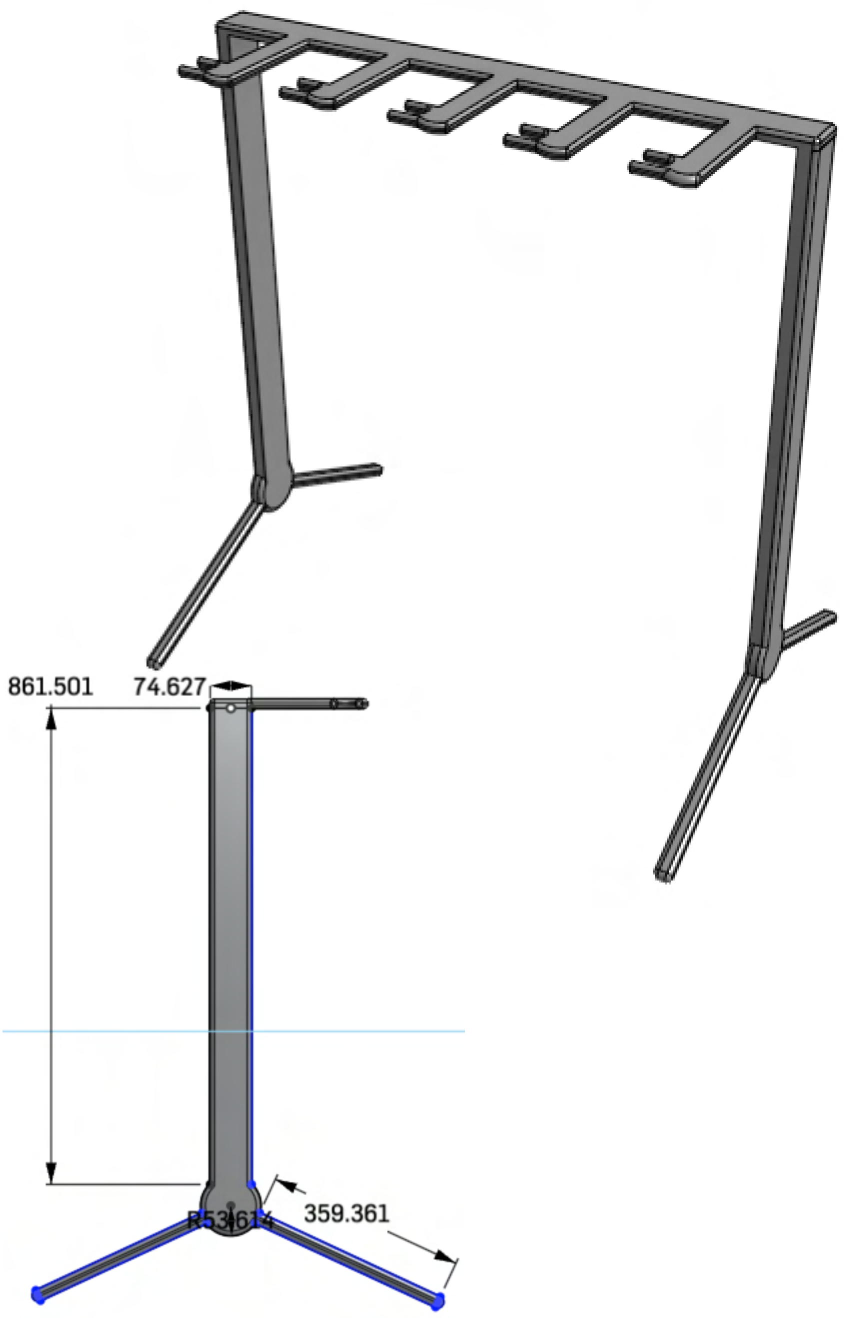


Figure 28: Images of solution 3

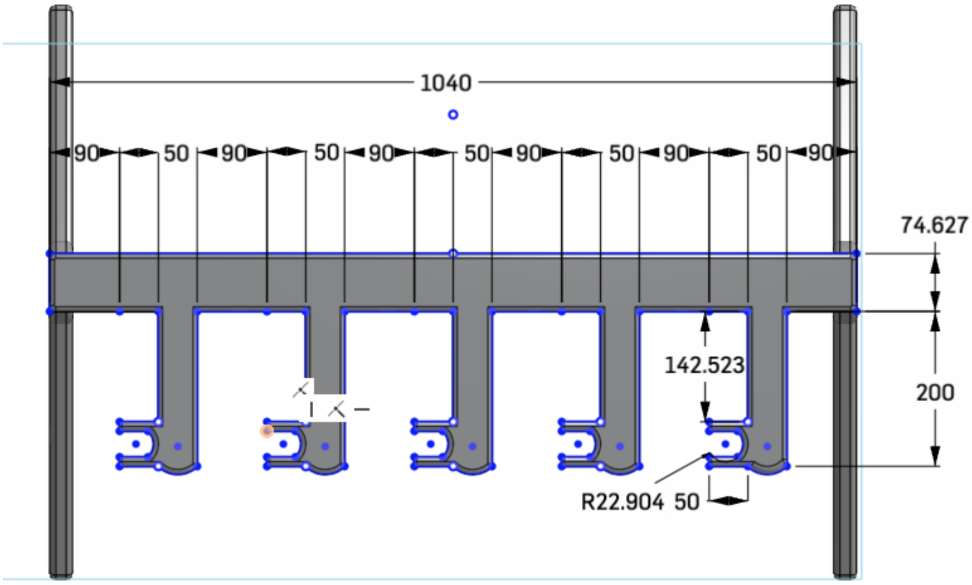


Figure 29: More images of solution 3

2.2 Evaluation of the Prototypes

2.2.1 Individual

The ability for someone to be able to store all their guitars efficiently irrespective of shape or size would have a significant impact on the individual, as they would not have to navigate through a maze of guitar stands and other clutter that can be found in music spaces. Furthermore, the folding nature of the stand means that it would be much easier for a single musician to load a car/van with all their equipment, as only one stand is needed, and there is more space for other items. As such, the impact of the stand on the individual would be a positive one.

2.2.2 Society

The impact of this product on the wider guitar community would also be positive, as guitarists all share common problems, with compact floorspace prompting a better storage solution being one of them. Many guitarists living or working with others would find this product useful for making their space tidier and easier to manage, as requested in the surveys earlier. Furthermore, guitarists working together can share a stand between 2 or more people, making the product viable for small bands.

2.2.3 Environment

This product would not directly impact the environment as it is not designed to be a product to do so, however, one of the criteria I have listed is that I would like this product to be environmentally friendly, meaning that whilst it won't contribute to actively reversing climate change, it won't contribute to it either. This means that after the end of the product's lifespan has been reached, or if the project fails horribly, there will be no negative impacts on the environment.

2.3 Justification of Preferred Design

My preferred design is solution 2. This is because the design is sleek whilst also serving its function. I see this as important because one of the results in the survey I conducted was that the rack that one person used is rather dull and detracts from the aesthetic of the room in which they keep their guitar, a subtle geometric aesthetic will help reduce the impact that the stand has on the room's aesthetic. Furthermore, the design of the rack allows all parts to become flat, as all the parts that extend can fold down, whereas with the other solutions there are still parts that extend from the main body when folded down. As a result, this option is best suited for function, and further improvements can be made as necessary due to the simplicity of the model. The simplicity means that only a few parts are needed and thus slightly more expensive parts that favour environmentally friendliness can be used whilst not increasing the overall theoretical price of the stand.

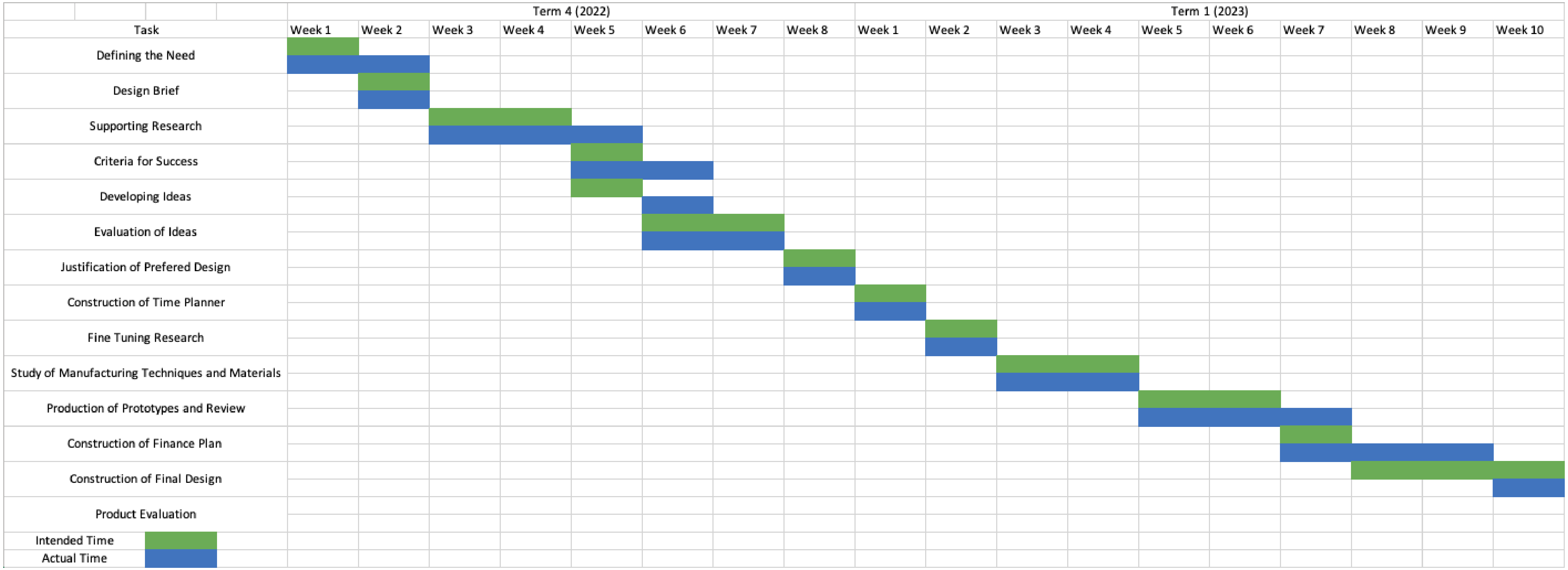
Figure 30: Chosen Design

Ongoing Evaluations: The whole process of modelling designs using CAD was quite revealing. It firstly made me learn some skills within the software that may serve me well in the future. It also made me consider other things that would affect the design such as materials and joints, and how I would actually join together various parts. The process of producing prototypes allowed me to refine my ideas into models that were much easier to visualise, and consequently give further insight into why some fared better whilst others failed. One of the key reasons I chose solution 2 is because it had no loose pieces involved meaning it would be easy to store, and because it had the simplest mechanisms of folding with few moving parts. Whilst I would have liked to try the clamp method of securing the guitars, my current skill set is not advanced enough to do so.

2.4 Planning For Production

2.4.1 Time Plan

Figure 31: Time plan detailing what I aim to achieve and when it is actually completed (graph continues over the page)



		Term 2 (2023)									Term 3 (2023)					
Task	Week 10	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Defining the Need																
Design Brief																
Supporting Research																
Criteria for Success																
Developing Ideas																
Evaluation of Ideas																
Justification of Prefered Design																
Construction of Time Planner																
Fine Tuning Research																
Study of Manufacturing Techniques and Materials																
Production of Prototypes and Review																
Construction of Finance Plan																
Construction of Final Design																
Product Evaluation																

Intended Time	
Actual Time	

2.4.2 Time Plan Evaluation

Term 4 2022

Week 1: The main goal of this week was to wrap my head around the scope of this project, and to start brainstorming ideas to identify a need. Due to the scale of the project, it took some time to brainstorm and come to a conclusion of what product I wish to make. As a result, I have only gotten through about half of what I would have wanted to do in the first week.

Week 2: Week 2 was primarily finishing up the identification of the need and working on the design brief. This included refining certain aspects such as how I came across the problem as well as who it would affect. This portion of the project ended up finishing on schedule.

Week 3: This week involved me conducting supporting research to provide justification of the guitar rack, which consisted of doing research into existing guitar racks. This made me realise that there is a genuine gap in the market for the product I am proposing, and, in addition, I actually managed to go and take photos of the storage systems in place in my home.

Week 4: Preparations for the assessment task started this week, meaning there was not 100% focus on the MPD. Nonetheless, I still continued to do background work on the MDP and worked on assembling the criteria for success and assembling the results of the survey, which was a key part of the assessment. Unfortunately, however, due to other components of the assessment, the criteria for success took a bit longer to complete.

Week 5: Having finished the criteria for success and areas of investigation halfway through the week, I then started to work on sketching and modelling ideas. These ideas would be used in the assessment task, so time was taken to make sure they were of a high quality, which meant confronting my fear of using Onshape (3D CAD Software).

Week 6: Due to the various backlogs of work at the time, I also worked on completing the ideas as I came up with them, which resulted in me clearing the backlog by the end of week 6. Much of this week was spent catching up on work and as a result, I felt relieved that I had A) cleared the backlog but B) also shown that I have the capacity to work under pressure. In addition, I also started (briefly) the evaluation of ideas.

Week 7: This week was spent on evaluating the ideas, and given the fact that the evaluations would also be used in the assessment meant that care was to be taken to ensure that the evaluations are justified and make sense.

Week 8: The final week before the term ends, this week was spent justifying design. This is because I wanted some fairly low stress work for the last week of term, not only because I was tired, but also because the assessment task was taking place this week, and I didn't want to take my efforts away from that too much.

Term 1 2023

Week 1: This week's main focus was consolidating the work after the summer break and putting together a plan for the foreseeable future. The main goal of the week was to put together a time plan, not only because it's required but also because it would help me stay on track. Whilst I ended up getting the job done, I feel as if the task could have been completed a bit quicker than it was.

Week 2: The main focus of this week was to start researching various pieces of information that would further streamline the production of the guitar stand. In order to accommodate various types of guitars in order to achieve the main goal, I need to know how much clearance I need. I managed to get the guitar dimensions done before the end of the week, meaning the 'fine tuning research' was done a little early, allowing me to start researching manufacturing techniques and materials.

Week 3: The main goal of the week was to look into what materials I could use to build the guitar rack. I spent most of my time looking into common materials used in guitar stands and decided upon metal, and then spent the remainder of the week looking into the best types of metal and decided upon aluminium alloy. I had a bit of time at the end of the week that was spent looking into different types of foam for padding. Whilst I would have liked to finish materials and move on to manufacturing techniques, progress is still progress.

Week 4: This week I really felt the pressure of finishing the prototypes before the deadline to start to build, so I decided to start doing the research of materials and manufacturing techniques at home to keep me on schedule. On a good note, I have a somewhat clear idea of what the 3 variants of my chosen design will be, meaning I can get a good start on the prototypes.

Week 5: The goal of this week was to complete the 3 prototypes, with one being a drawing, one being a CAD model, and the last being a physical model. The drawing and CAD model were to my surprise not that time consuming as my experience with onshape has grown in the last few months. Whilst there was a slight issue with the laser cutter such as, I was also able to produce the physical model within the week, allowing me to spend the weekend and the first half of next week evaluating the designs.

Week 6: This week was focused on finishing the parts of the MDP required for the assessment, meaning finishing the physical model of the prototype. This went surprisingly well, and showed that the design has merit, which is a major confidence boost for me given that I am undertaking a challenge that is actually working so far. The next phase is to look into various fields that can further develop the design that I have chosen.

Week 7: This week was focused on looking into the inner workings of various mechanisms to see how they can make my product better. Whilst I was able to identify what types of mechanisms I need, it is rather annoying to find some places that sell the components I need despite them being rather common. Furthemore, I took a trip to a shop that sells metal with a classmate who pointed out the shop, where I found out that the type of aluminium I use is negligible for the purposes that I need, so I might as well go for the cheapest option rather than the 1100 grade that I originally envisioned, and may even go as far as using a different metal.

Week 8: This week was a good week. I ended up going to another shop that sells metal and there are rolled sheets that might be the perfect size for what I am making. In addition, I made the finance planner which was a lot easier than expected meaning I could move on to making a full scale prototype to determine the exact measurements that I need. This resulted in me not being behind schedule.

Week 9: This week I focused on finalising some part measurements to put together a parts list. This was beneficial as it will allow me to produce a full scale prototype to test whether or not these measurements were correct or not. Furthermore, the full scale prototype would allow me to make any changes if needed to the design to make it function better.

Week 10: This week was a handful, as although there were only 2 lessons due to public holidays and school events. Firstly, I started construction of the rails for the full scale prototype by marking out measurements on some dowel that will be replaced by steel in the final product. And secondly, we had a class discussion about some of our products, and this opened my eyes on some of the unforeseen potential applications of my product. For example, other people saw a use for schools and music retailers, with the concept of easier storage for many different guitars being a strong suite of the design. Others said that due to the flat nature of all the different parts that it could be a flatpack, self assembled design. Whilst this won't change the design of the stand, it does make me think of what could have been done differently, and the potential for such a product.

Term 2 2023

Week 1: Progress this week was good, mainly because I had a day where I could spend the entirety of it in the workshop. This allowed me to put together the full scale cardboard prototype which yielded valuable results, the first of which was not to build out of cardboard. The structure was too flimsy for its size as there are considerable differences between the strength of cardboard and metal. In order to test the measurements of the product fully, I will remake the side stands and top neck holders out of plywood, as this is stronger and will be able to support itself.

Week 2: Much progress has been made, but also several changes. The prototype is nearly completed, meaning I can soon bring in a guitar to test whether or not the measurements work before I then create the final product. There have been some changes though, with the legs being unable to move due to a temporary solution to fixing the legs in place, which will need to be addressed in due time. Furthermore, the prototype does not use bearings, meaning a series of bolts have been used to fasten the rails to the frame, which whilst acting as a good temporary solution won't be good in the long run, and will also need to be addressed.

Week 3: I finished the prototype this week which is a good step in completing the project. I was able to evaluate the measurements, and for the most part they were sound. In addition, I was able to bring in a guitar to test whether or not the prototype worked, and it did, which was a huge relief. However, whilst the prototype could hold a guitar, the legs still needed the folding mechanism to be engineered.

Week 4: Not much was done this week due to the DT assessment and excursions, meaning I will need to do better next week once the test is done. On the flip side I was able to get my friend to bring in two of their guitars to test on the prototype and they fit, but also met the same friction issues previous guitars had due it being used on velcro instead of rubber.

Week 6: The last 2 weeks were spent working on the Adobe file to make sure the measurements are right and revising methods of fastening the legs to the frame. The previous methods thought of as push pins, where there is a pin you push into the frame in order to allow rotational movement has been replaced with what seems to be a better concept of spring concepts in which you pull out a pin attached to a spring. This will make the legs a lot easier to operate as it makes the locking mechanism more spaced out whilst not sacrificing tons of space.

Week 8: Due to the slowing rate of development (building takes a while) I have moved to evaluating every two weeks. Progress has slowed further due to attention being focused on school events, however, I have spent time researching various spring plungers and starting construction of the final design. This gives me a solid 2 months to get the design built and evaluated.

Term 3 2023

Week 1: Due to trial exams progress has slowed, however I have the revised measurements for the sides figured out, the rail structure built and the spring plungers have been ordered. I also made a trip to the shops to pick up some foam padding for relatively cheap, which puts this project quite under budget which is rather helpful.

Week 3: Very little was done this week. I went in between exams to sand some wood and fit the foam to the rails, which may need another layer, which set me up for a bit of time pressure once exams finished.

Week 5: Now that trials have finished all work is being focused on the MDP. This week in the workshop I spent time finishing the final product, whilst at home I spent time making sure that the documentation side of the project is up to scratch. Whilst I have been able to focus all my effort on the MDP, I feel as if the approaching deadline (only 4 days away at this point) means that I will start rushing and not getting the best quality work done. The prototype, whilst functional, could definitely be better if I had more time and less things to worry about outside of DT.

2.5.1 Appropriate Research

One of the main goals of this project is to ensure that this stand can accommodate all types of guitar shapes. Whilst I have a few at home, there are more types out there, as such I will need the general dimensions of neck shape, size, and body dimensions. There are several guitar shapes out there and each has their own dimensions.

Stratocaster

The Fender stratocaster is probably the most iconic shape that people most associate with the 'guitar' in general. Important features to note are the curved base of the guitar body, meaning that it can rest between two bars like the cradle method mentioned earlier.

Body Dimensions:
Width: 323mm
Length: 461mm
Depth: 44.5mm
Source: (Binyamini, n.d.)

Gibson Les Paul

The Gibson Les Paul is another notable guitar shape, known for its rounded base and acoustic-like shape. Important features to note are the fact that the base is an almost perfect curve, meaning that if the neck is not supported, the guitar body could slide down.

Body Dimensions:
Width: 330.5mm
Length: 555mm
Depth: 61mm
Source: (Gibson Les Paul Guitar: Price, Review and Opinions, n.d.)

Gibson SG

The Gibson SG is also another popular body shape, used by many famous musicians such as Angus Young from AC DC. The shape is known for its pointy cut outs on both sides of the neck for ease of access to the higher frets. Important features to note is the rounded shape of the base of the guitar, which is similar to that of the fender stratocaster, as well as a thinner neck.

Body Dimensions:
Width: 330mm
Length: 481mm
Depth: 32mm
Source: (Gibson SG Standard Solid Body Electric Guitar (1969) | RetroFret, n.d.)

Chapman V

The Chapman V is a special type of Flying V that has sharper edges and a more vibrant colour scheme. Whilst this is not the most common Flying V out there, it is the model that I have, making it of some importance to this stand if I am to test it properly . Important features to note are the lack of a rounded base, a longer base, and two wings that span out, meaning a cradle method will work provided it is high enough. Furthermore, other Flying V guitars will have similar bodies, meaning that the measurements for this stand will be compatible.

Body Dimensions:
Width: 462mm
Length: 518mm
Depth: 40mm
Source: Primary measurements

Gibson Explorer

The Gibson Explorer is a unique shape in the way that it is a pain to store. One of the participants of the survey I sent specifically mentioned that they have an explorer and that it's rather difficult to store. The geometric lines and wide body meant that it quickly became popular amongst hard rock and metal musicians, such as James Hetfield. Important features to note is the wider profile of the guitar and the slanted angle of the base, meaning that the guitar can slide off the stand if there isn't adequate friction.

Body Dimensions:
Width:421mm
Length: 521mm
Depth: 43mm
Source: Primary measurements

Ibanez RG Series

The Ibanez RG series is like the Stratocaster body, in the sense that it is very common amongst their guitars, but also because it is pretty much the Stratocaster body but with sharper edges. Important features to note are the flatter base and a bigger depth than most guitars.

Body Dimensions:
Width: 302mm
Length: 449mm
Depth: 46mm
Source: Primary measurements

Neck Size

The neck size for electric guitars are all pretty much the same, and range from 17mm to 26 mm wide, and around 20mm deep, although it can vary. (Heather, n.d.)

Ongoing Evaluations: From these measurements it can be seen that there must be at least 7 cm of clearance for depth, the neck support needs to be at least 600 mm above the cradle to allow for the clearance when placing a guitar on the rack. The width of the neck holder must be at least 40mm for clearance as well, and there needs to be 500 mm of clearance for the width of the body.

2.5.2 Study of Manufacturing Techniques and Materials

Materials

Whilst the size parameters of the guitars are important, study of how to assemble a guitar stand is also needed in order to make this product successful. The most common materials used in guitar stands are wood, steel, and plastic, however plastic, whilst cheap, is not very durable and is not environmentally friendly. Wood and steel offer good durability and can be recycled, and are ridgid and offer good support (Stoneybrook, 2022), however there are various types of wood and steel out there.

Wood is environmentally friendly, and is also easy to shape, as many basic workshop tools can easily shape wood, such as saws and a Jack Knife. However wood also has some interesting properties. Wood can absorb water, meaning that over time it will soften and rot given the porous nature of the material (*Escarosa*, n.d.). Furthermore, different types of wood with different levels of stiffness, using the Janka rating which is an industry standard. According to *Top 10 Hardest Woods in The World*, 2022 the top 5 stiffest woods are:

1. Australian Buloke, 5,060 IBF
2. Schinopsis Brasiliensis, 4,800 IBF
3. Schinopsis Balansae, 4,570 IBF
4. Lignum Vitae, 4,500 IBF
5. Piptadenia Macrocarpa, 3,840 IBF

Given the results above, there is not much difference between the 5 types of wood in terms of stiffness. When compared to the stiffness of oak (1,350 IBF) (*Janka Hardness*, n.d.), there is some level of difference, however, the stiffness is representative of how resistant the wood is to dents and various other physical stresses the product might face. Furthermore, when the time comes to build said stand, the wood will need to withstand the weight of multiple guitars, and supply also comes into the equation. Having looked through multiple supply retailers such as Bunnings, it seems that Australian Buloke is quite rare. As a result, a metal stand seems like the best option.

When it comes to metal, there are a variety of types available, and they are easily recycled. Furthermore, when it comes to guitar stands, there are a lot of existing metal ones, and when doing research of existing designs, most of the multi guitar stands are made of metal.

In order for this guitar stand to be folded down and transported easily, the metal would need to be fairly lightweight in order for it to succeed in accomplishing its goal.

Therefore, there are only a few metals that would suffice. Having looked at the web, aluminium, beryllium, titanium and magnesium alloys all have high strength to weight ratios (*Properties and Production of Lightweight Metals*, 2016). Given the uses in the aerospace industry due to its strength and heat resistance, and the fact that titanium is generally expensive and overkill, aluminium seems to be the best option.

Aluminium alloys are non ferrous, meaning that they do not contain iron giving them corrosion resistance (*Properties and Production of Lightweight Metals*, 2016). In addition they are also lightweight, ductile and have excellent strength given their weight.

There are different types of grades of aluminium that determine the qualities of the alloy and in industrial applications, the end use of the alloy as well. There are 3 main types of aluminium alloys, 1100, 3003, and 6061, but there are also other grades such as the 5000 and 7000 series (*Different Grades of Aluminum and Their Applications*, 2021). The different grades have different compounds and applications and as a result, there is a specific type of alloy that might work for this project.

1100 Grade

With 99% mineral purity, 1100 grade aluminium is the purest form of aluminium alloy commercially available. The metal does not harden when worked or heated, it has excellent corrosion resistance, and it has high thermal conductivity and can be welded, which makes it a versatile metal. Given the versatility of the metal, it can be shaped into many products, examples of these are chemical equipment, railroad cars and various dials and gauges used in industry (*Different Grades of Aluminum and Their Applications*, 2021).

6061 Grade

This is a medium strength grade of aluminium alloy with more corrosion resistance than other grades. The other benefits are the high heat welding capabilities and the strength to thickness ratio compared to other metals. The alloy is part of the 6000 series which are the main product of commercial forging process of hot extrusion, making the metal readily available (*Properties and Production of Lightweight Metals*, 2016). Some applications of 6061 grade aluminium alloys include making rivets, aerospace applications and beams on bridges.

3003 Grade

This is a relatively pure grade of aluminium but uses manganese additives to increase its strength. Its main components are 98.6% aluminium, 1.2% manganese, and 0.12% copper (*Different Grades of Aluminum and Their Applications*, 2021). Whilst this grade has less corrosion resistance than the other grades, the metal is readily weldable, relatively low cost and can be used in most applications, meaning it is an economical alternative for the domestic purpose that this stand will seek to achieve. Common applications of this grade are cooking utensils and pot lids, however there is not enough heat resistance to cope with temperatures found inside an oven, however for the purposes of this stand, temperature properties are negligible.

Ongoing Evaluations: Given the different types of aluminium available, the 3003 grade aluminium seems to be the best option, as all the other types seem rather overkill due to their extreme heat resistance making them useful in the aerospace industry. However, this stand will not be entering the atmosphere at thousands of kilometres per second, meaning the low cost 3003 grade is more suited. Furthermore the capacity for the metal to be readily weldable makes it easy to use as well, meaning no preparations would be needed. Whilst the aluminium might be the main material involved in this product, there is also a need for some form of material to prevent the metal from damaging the guitars when placed on the stand. Foam and rubber are materials that can be seen on all guitar stands as they provide adequate padding and protection against scraping that could damage the finish on the guitar. According to Foam Online (*Foam Types - Definitions, Qualities and Common Uses*, n.d.), there are various types of foam and rubber available and there are various pros and cons to all of them.

Dry Fast Foam

Dry Fast Foam is good for outdoor purposes as the foam is resistant to wear, does not absorb water, and is resistant to mould, rot and mildew. The foam's water resistant properties make it useful in filtering or padding that is subjected to high levels of moisture and water. It has an open cell structure, meaning that the air bubbles within the foam are not closed off, and can send air through to other bubbles and eventually the outside air, meaning that the foam can bounce back into its original shape. The foam tends to last 8 years giving it decent longevity, however if it comes into contact with a flame then it will catch fire.

Closed Cell Foam

Closed Cell Foam is also non water absorbent, however unlike the Dry Fast Foam, it floats and is impervious to petroleum. The non biodegradable nature of the foam means that the foam will last approximately 15 years, making it rather durable. Closed Cell Foam is a type of foam in which the cells within the foam are entirely closed off from each other and the outside world. Whilst this has excellent durability, if the cells are popped due to extreme circumstances then the foam loses part of its padding properties.

Polyurethane Foam

This was the original foam that other foams on the market are based off of. Polyurethane foam is an open cell, low density foam that has good uses in the packaging and shipping industry due to its soft nature. The downside is that the foam has low resilience to forceful knocks, which may occur during transport. The foam has a lifespan of 2 years, meaning that the foam would not be environmentally sustainable. Having looked at the various types of foam available, the closed cell foam looks to be the most convincing due to its high resistance to the elements and long lifespan. However, there is also the potential for using rubber as a form of padding. There are many different types of rubber sheets and padding available, consisting of different compounds. Each compound has its own unique applications and strengths and weaknesses. According to CSI (*Types and Applications of Industrial Rubber Sheeting*, n.d.) some of the most common types of rubber sheeting are:

Styrene-Butadiene Rubber (SBR)

This is a general purpose rubber which has similar properties to natural rubber (mentioned below) with a wide range of applications. The enhanced resistance to heat, water and abrasion make it more durable than other types of rubber. The low cost nature of the rubber sheeting makes it ideal for domestic applications, and has the capacity to withstand dilute chemical spills as well.

Chloroprene Rubber

Also known as Neoprene Rubber, Chloroprene Rubber is also a versatile allrounder. Its allrounder solid qualities give it good resistance to heat, chemicals, liquids and UV radiation. Furthermore, the rubber can be used in both industrial and domestic properties, such as wetsuit manufacturing and some commercial kitchens.

Natural Rubber

Natural Rubber is the result of processing the latex of rubber trees, meaning it is somewhat environmentally friendly. The high flexibility and durability combined with the resistance to abrasion and wear makes it good for protective applications, such as screening and shotblasting. However, the natural origins of the rubber mean that it cannot be exposed to solvents, various chemicals, oils and ozone.

Manufacturing Techniques

Whilst it is important to consider the materials needed to build a product such as this guitar stand, the ability to put all the materials together in order to make the product work must not be overlooked. As the only metalworking I have done before is making a small shovel, so whilst I know how to cut metal, a refresher is needed. There are some basic metalworking techniques that I can test. The main functions of metal working according to The Crucible Industrial Arts (Arzt & guide, 2022), are:

- **Cutting:** this entails removing material from the metal by methods such as millsing, routing, turning, sawing and CNC.
- **Joining:** this involves combining two pieces of metal using heat and pressure in methods such as welding and soldering.
- **Forming:** the process of reshaping the metal without removing or adding any material, such as forging and bending.
- **Casting:** Shaping metal by heating it into a liquid state and pouring it into a mould to shape the metal to a specific shape.

Arguably, the most important techniques that are unknown to me for this product would be welding and forming, specifically bending the metal into the desired shape. As such, I should probably look into the various forms needed before experimenting with the techniques.

Welding

According to the New England Institute of Technology (*4 Different Types of Welding Processes 2023 - NEIT*, 2020), there are 4 main types of welding processes, GMAW, GTAW, SMAW and FCAW, however each method of welding uses the same principle. An electric current is used to create an electric arc between an electrode and the metal workpiece, heating both metals past their melting points to allow a joint to be formed. According to the Universal Technical Institute (*Welding Joint Types: Butt, Lap, Tee, Edge Joints & More | UTI*, 2020) there are five basic joints that can be formed.

Butt Joint

Butt joint welding is a joint in which 2 pieces of metal are placed together on the same plane and have their edges welded together. The joint is most common in the fabrication of structures and piping industries, meaning it should be fairly simple to construct the frame for my project using this method in conjunction with others.

Figure 32: Diagram of a Butt Joint

Tee Joint

A Tee Joint is where 2 pieces of metal are placed parallel so they intersect at a 90 degree angle forming a T shape. When preparing a T joint, there is a plain Tee Joint in which both metals have flat edges and there are other types of joints where the piece that is being welded to the middle of another piece has certain parts removed for better penetration of the welding arc.

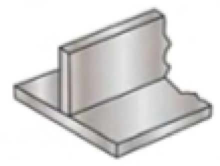


Figure 33: Diagram of a Tee Joint

Corner Joint

Corner Joints are basically the same as Tee Joints. The only difference is where the metal is placed in relation to the base metal, and hence the name, is usually placed near the edge of the base metal to form a corner. These joints are commonly used in the sheet metal industry, often being used to form frames, making it also useful for this project.

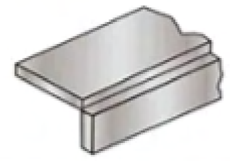


Figure 34: Diagram of a corner joint.

Lap Joint

Lap Joints are similar in principle to Butt Joints, the only difference is the size of the faying surface (the surface that is welded). Two pieces are placed on top of each other to form layers, and are commonly used in the sheet metal industry to join together two pieces of varying thickness.

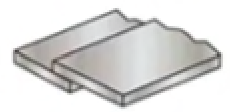


Figure 35: Diagram of a lap joint.

Edge Joint

In an Edge Joint, the sheets are placed together so their edges align. An Edge Joint is used to distribute any forces acting upon the metal evenly to ensure durability of the joint, however, for the purposes of this product, Edge Joints might not be relevant.

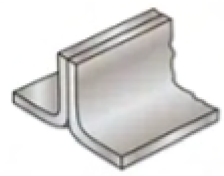


Figure 36: Diagram of a lap joint.

Ongoing Evaluations: Having looked at the various types of foam and rubber available, the rubber sheeting seems to be more preferable, simply because all of the other specific applications of the alternatives are rather overkill, as the guitars will not be coated in a potent acid or anything like that, meaning that the general ability to be soft, which pretty much all forms of foam and rubber possess is the only thing that is needed, meaning the cheapest form of natural rubber sheeting will be used, given that it is the most environmentally friendly option. Furthermore, there seem to be a variety of welding joints that can be made with 2 pieces of metal. This can provide me with options for how I choose to construct the final product. Even the simplest method, a butt joint seems to be strong enough to serve the general purpose of the stand.

2.6 Production of Refined Prototypes

To ensure that the final product is the best form it can be in, I will create 3 prototypes that are variations of the chosen design. These will all adhere to the measurements that the guitars require to be stored safely.

2.6.1 Prototype 1

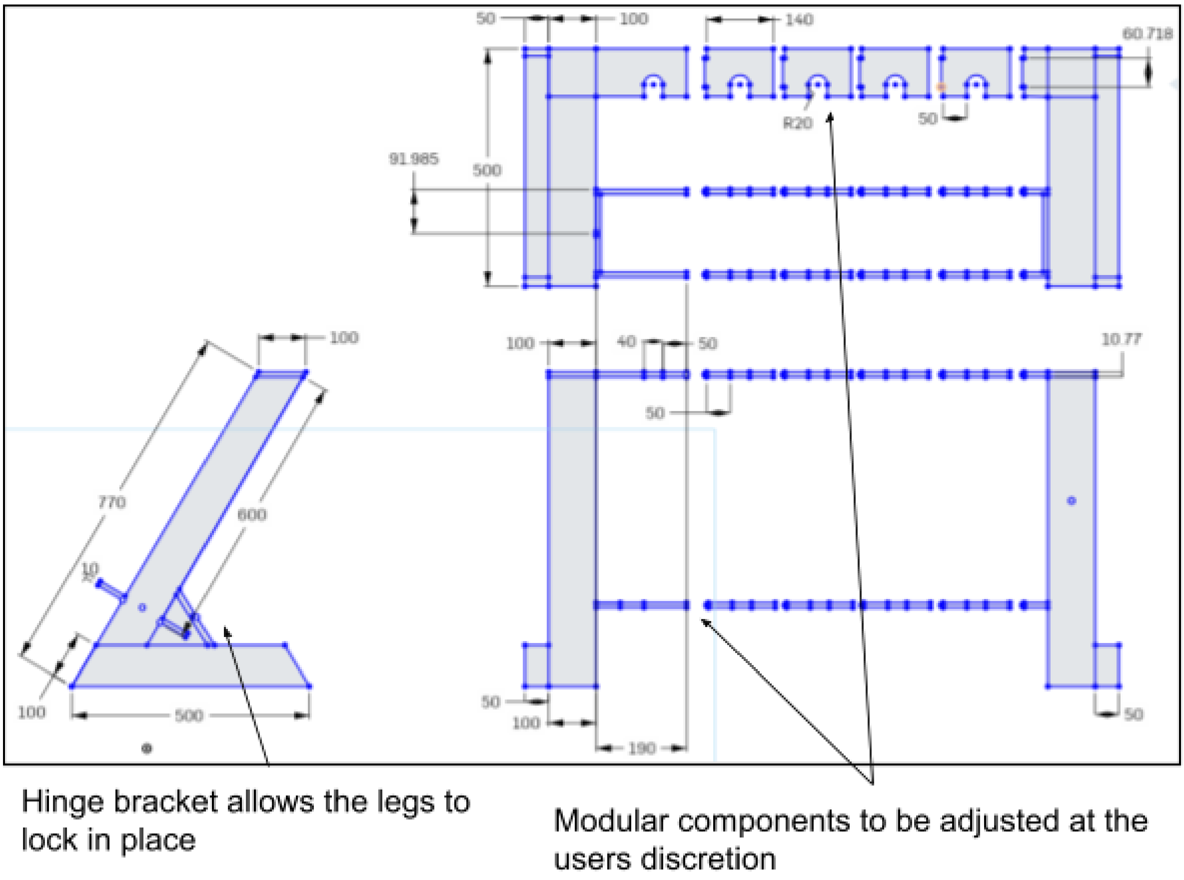


Figure 37: Technical drawings for the first prototype. Measurements in mm.

This first prototype is probably the most far fetched of the three that I will produce. The whole idea is that the guitar rack is modular, with the user being able to adjust the length of the rack to accommodate any number of guitars they own by slotting on more neck holders and cradle tubes. The parts would lock together with a lego-like 'stud system' perhaps with magnets as well for added bond strength.

SWOT Analysis

Strengths	Weaknesses
• Modular design allows for customisation depending on consumer needs • Smooth rails allow for acoustic guitars to also be placed on the stand • Despite the modular design, the stand can still be collapsed • Can hold 5 guitars • Can fold into a smaller position • Given that the stand will be made of metal, it can be recycled	• Modular design means that structural integrity is compromised • More components results in a higher cost • Increased difficulty in using the product • Support legs are on the outside of the frame, resulting in a wider profile, thus taking up more space • Whilst the rail system in theory can hold multiple shapes, it cannot be proven with this design.
Opportunities	**Threats**
• No other product like this has been identified on the market so far • There is a legitimate need for a product that can hold multiple guitars of different shapes.	• My skill level is not high enough for me to feasibly attempt such a design • Potential difficulty in sourcing the right materials • Engineering the modular locking system will be difficult

Figure 38: SWOT analysis of Prototype 1

2.6.2 Prototype 2

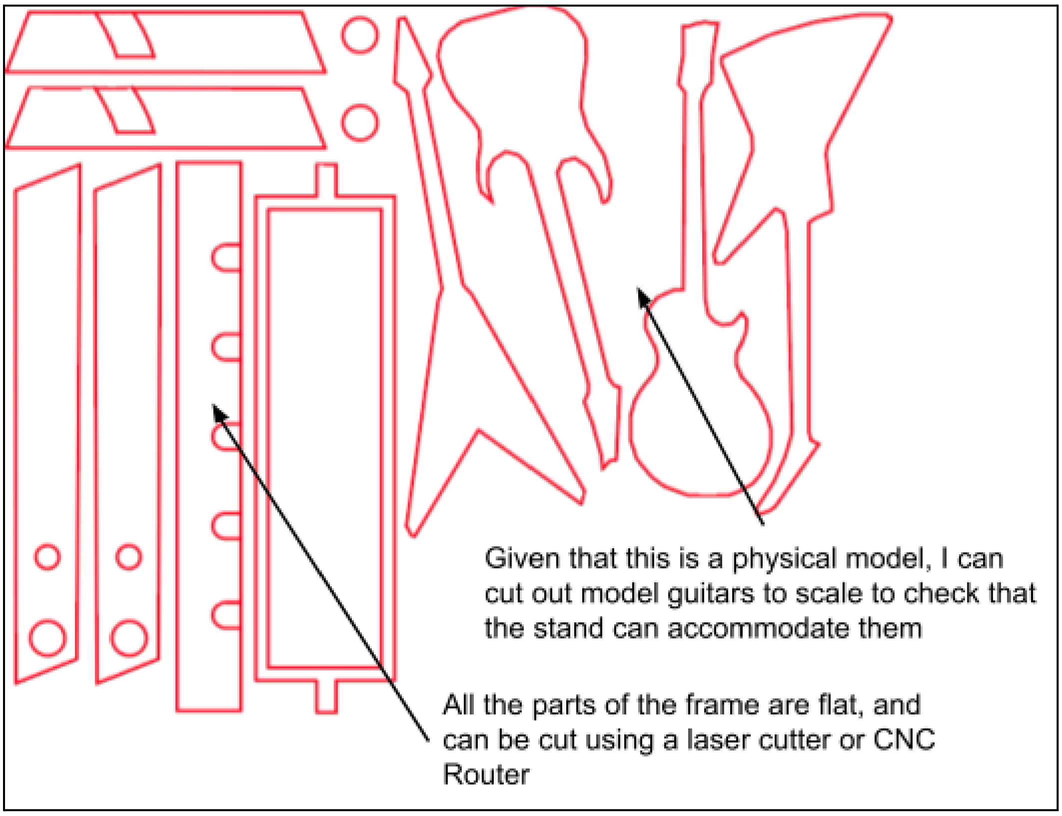


Figure 37: Screenshot of the Adobe Illustrator file.

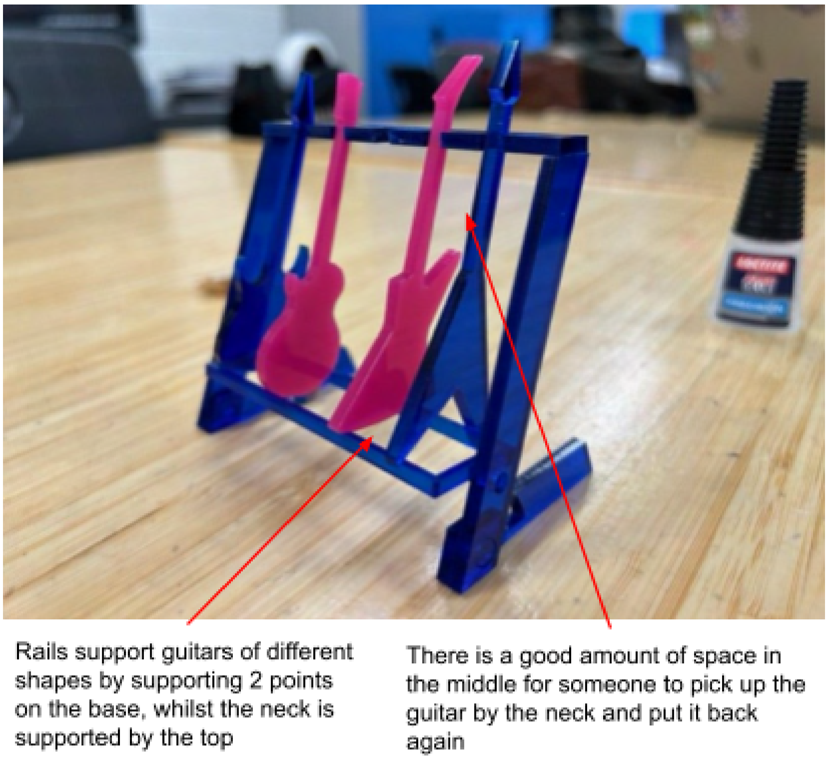


Figure 38: Second prototype design holding scale guitar replicas

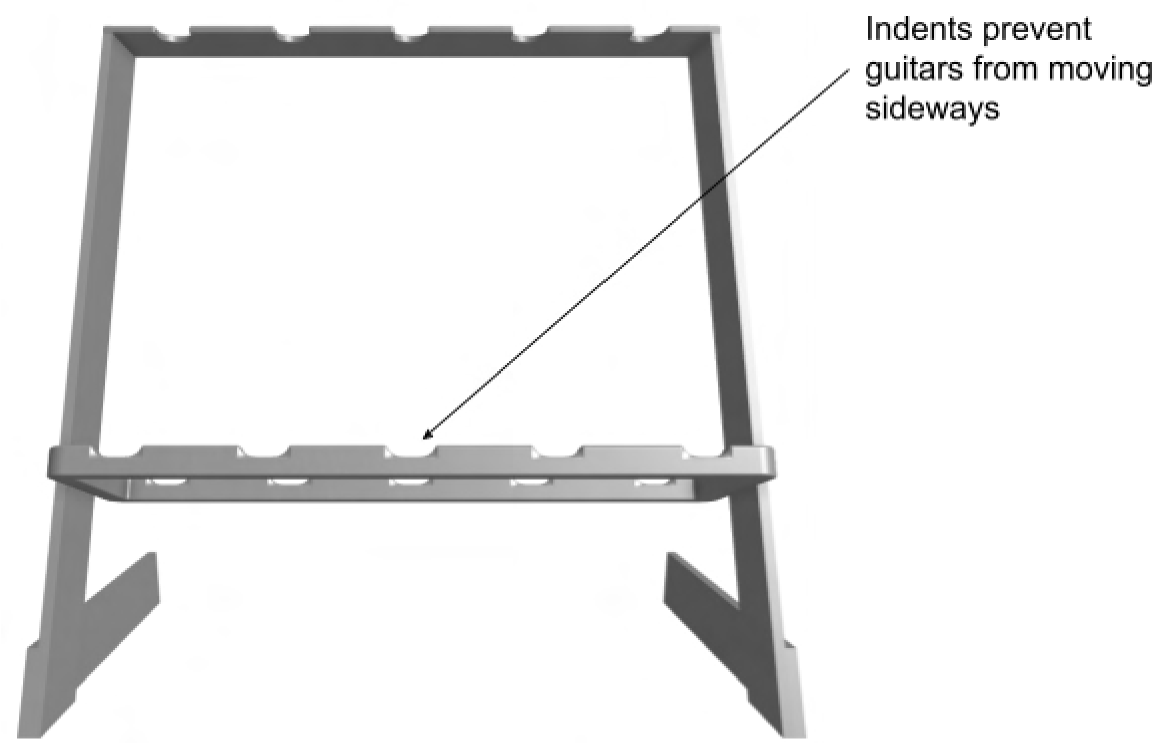
The main feature of this design is that the legs that fold down to support the stand are on the inside of the frame compared to the outside like previous designs. The legs have small cut outs to allow them to fold up without being blocked by the mounting points for the rails. Furthermore, the rails can rotate to become flat with the rest of the stand. Furthermore, the legs and main support beams for the stand have a much thinner profile than other designs.

SWOT Analysis

Strengths	Weaknesses
• Support legs are on the inside of the frame, meaning a reduced side profile • The design is not modular, meaning increased structural integrity • Simple and easy to use • Can hold multiple shapes of guitar • The stand can be folded flat • It serves the intended purpose • Will be easy to produce	• To accommodate the legs being on the inside, the support legs have cutouts to allow them to fold up without interfering with the rails, thus potentially compromising integrity • Lack of modular components means the user is stuck with the 5 slot design, making it unnecessary for small collections
Opportunities	**Threats**
• No other product like this has been identified on the market so far • There is a legitimate need for a product that can hold multiple guitars of different shapes.	• Potential difficulty in sourcing the right materials • There are other guitar stands in the market that can cater for people who do not own varying shapes such as explorers or flying Vs

Figure 39: SWOT analysis of the second prototype

2.6.3 Prototype 3



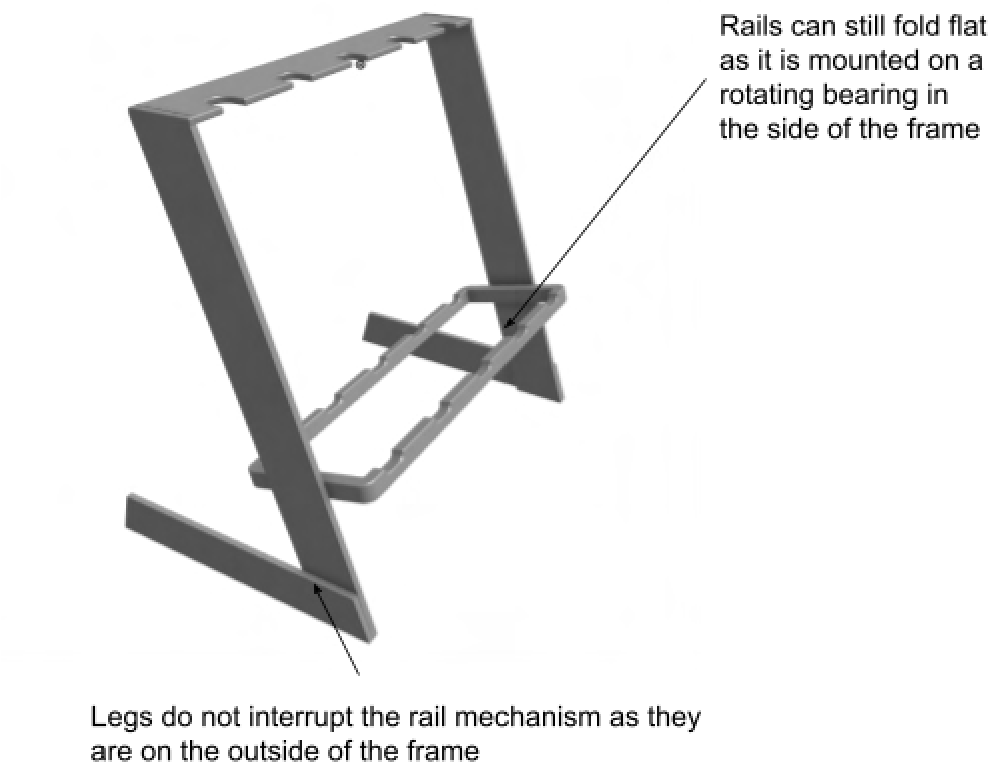


Figure 40: Images of the 3rd prototype

The idea behind this design is that instead of having 1 set of smooth continuous rails to hold the base of the guitar, there would be specified slots to hold the base of the guitar. Like the first prototype, the support legs are on the outside. It is not modular and is designed for 5 guitars.

SWOT Analysis

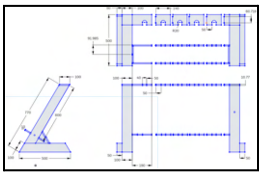
Strengths • Specified slots provide an added layer of support for guitars. • Slots provide security against lateral knocks of the stand, prevening the guitars from sliding sideways	Weaknesses • The slots determine the maximum depth of guitars that can be put on the stand, meaning acoustics cannot be used on this stand. • Support legs on the outside of the structure mean the stand has a wider profile, thus taking up more space
Opportunities • Could be used to tailor for customers that live in an unstable environment	Threats • Potential difficulty in sourcing the right materials • There are many people who own acoustics, and there are other stands that allow for storage of acoustics, meaning the stand would not provide any usefulness to them

Figure 41: SWOT analysis of the 3rd solution

2.6.4 Comparison of Prototypes

The following PMI table compares the 3 different prototypes in order to arrive at a conclusion at which is best.

Figure 42: PMI comparing the latest solutions

Design	Positive	Minus	Interesting
 Prototype 1	• Modular • Still folds flat • Customisable to suit the customers needs	• Complex to build and use • Integrity compromised • Higher theoretical price	The method that the guitar stand uses for its modular components means that the stand could in theory hold more than 5 guitars.
Prototype 2 	• Narrow profile • Fewer pieces • Easy to use	• Compromised leg integrity • Fixed length	The ability to have the legs on the inside of the frame not only results in a smaller profile, but also the aesthetic benefit.
 Prototype 3	• Prevents sideways lean of guitars • Protects against sideways knocks on the stand • Easy to use	• Cannot support acoustics • Limits the number of guitar options due to the depth of the body • Wider profile	The flat nature of the cradle means that it might be easier to put rubber padding on the surfaces that come into contact with the guitar.

2.6.5 Chosen Design and Justification

For the remainder of the project, I will develop the second prototype. This is because the second design provides the most benefits with the least amount of drawbacks. The thinner profile from the legs being on the inside of the frame result in a cleaner looking stand, and whilst the legs will have cutouts to allow them to fold up, the fact that this design will most likely end up being made out of metal, meaning that there will still be a considerable amount of support for the stand. Furthermore, the smooth rail means that even acoustic guitars can be placed on the stand, making it more effective at serving its purpose. The only downsides are the fact that the stand won’t be able to prevent guitars from leaning sideways, however, the friction from the padding would give enough protection that having the stand sitting stationary without being knocked frequently would be adequate for guitar safety.

Ongoing Evaluations: The process of evaluating the proposed prototypes has allowed me to identify what will work and what won't in terms of feasibility. Whilst some of the designs may have worked better in a real world application, or had more possibilities if taken further, looking at some of the designs and thinking about how I would construct them with the techniques researched earlier made me realise that sometimes simplicity is the best option when you're working with limited skill set

2.6 Further Development

2.6.1 Rotating Rails

In order to see this design reach fruition, I will need to develop it further. Preliminary testing shows that the design has merit and is capable of holding scale models of guitar shapes. However, there are two mechanical components that are essential to the design, those being the hinge that the legs use to fold up and the ability for the rails to rotate flat with the design. For the rotating rails, I will conduct some research into existing methods of making things rotate, such as mechanical systems and components. This will allow me to experiment with different types of rotors to allow the rails to swivel. Possible experimentations include making scale prototypes of hinges and testing the rotation of the rails.

In addition, the leg folding is also needed. The most efficient method would be to have a locking table leg hinge like the ones found on camping tables, combined with a similar rotor mechanism used for the rails. This will allow the legs to fold easily, whilst also locking into place to prevent the stand from collapsing in on itself. I will use a similar method of research and experimentation that I would use for the rotor, by looking at existing examples, making physical prototypes. This would allow me to iron out any kinks and make sure that the mechanism works.

In order to construct the mechanism that allows the rails to rotate flat, a rotating joint is needed to allow the two bodies to rotate with respect to each other. The most basic form of this swivel joint is to simply carve a circular hole in one object and have a shaft (axle) resting in it (*CSC 297 Robot Construction: Joints*, n.d.). This will allow rotation of anything fixed to the shaft, however there are various flaws with this simple state. The axle can be machined away if there is no grease or lubricant, and there needs to be minimal friction in order to keep both bodies stable when being used, which

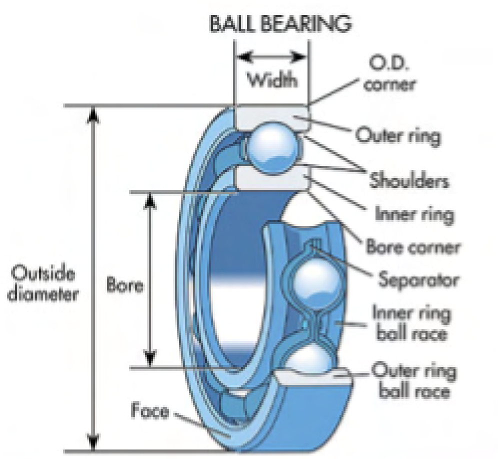


Figure 43: Diagram of a ball bearing

increases durability. A known solution to these issues is to use a ball based joint known as a bearing/ball bearing (*CSC 297 Robot Construction: Joints*, n.d.).

A ball bearing is the most common type of bearing used for rotating objects (*What Is a Ball Bearing and Where Are They Used?*, n.d.). The theory behind ball bearings is quite simple. It consists of 2 rings with spherical indents, and a series of metal balls in between the two, allowing low friction rotation, meaning it is easy to rotate. The bearing must be lubricated in order to prolong the life of the bearing. Given the fairly simple nature of ball bearings, I shall use those to enable the rotating components of the design.

2.6.2 Locking Hinge Brackets

The next mechanical part that needs to be addressed is the hinge mechanism. The main principle behind the hinge is using an axle known as a pin with two other bodies attached to it. The bodies are designed in such a way that the two bodies can rotate with respect to a single mounting point.

Figure 44: Diagram of a butt hinge

However, due to the nature of the arrangements of the metal sheets in this guitar rack design, a rotating mechanism would seem more appropriate. Yet, this would lead to the stand not being able to support its own weight, and simply falling over. In order to solve this problem, a locking hinge bracket can be used to give support to the legs. The locking hinge brackets work by having two arms, with three hinges, two on the ends and one in the middle. The hinges on the end allow for the whole mechanism to fold flat, but when extended, the centre hinge extends slightly past the centre axis, and due to physical restraints on the centre axis, the hinge is incapable of further movement unless it is in the reverse direction, thus locking the hinge. (Morton, n.d.) If positioned correctly, these hinge brackets can work with the unique angle of the guitar stand, and can be an easy to use solution to the problem of the folding legs. The ease of use can be further improved by removing resistance to the legs moving against the vertical components of the frame by using a bearing to attach the leg to the frame, and using the hinge bracket as a method of securing the legs at a certain angle.


Figure 45: Image of locking hinge brackets

2.7 Finance Plan

Now that I have a clearer picture of what I am making and what I am making it out of, I can locate the materials needed and put together the prices for the ideal components to see how expensive this stand will cost.

Figure 46: Finance Plan

Part	Intended Price (Aud)	Actal Price (Aud)
Aluminium Sheet Metal 300mmx770mm	106	0 - Ended up using bamboo wood already in the DT department.
Ball Bearings x4	14.80	0 - Ended up using bolts and dowel in the DT department.
Locking Hinge Brackets x2	9.18	0 - Ended up using hand tightened screws already in the DT department
Steel Rod 2m	10.50	0 - Ended up using dowel already in the DT department
Foam Padding	25.50	12.50
Screws	0	0 - screws supplied by DT department at no cost to me
Total	140.48	12.50

Ongoing Evaluations: For this project I was assigned a budget of $200 to purchase any resources or materials needed from my DT department. Having actually added up all the costs of items that I needed to purchase, namely the foam padding, it is evident that this project went way under budget than what was originally planned. The cause of this can be attributed to the fact that I decided to make the full scale prototype out of wood rather than metal so as not to waste valuable materials. However, after making the prototype and consulting the DT department's technician, we decided it would be better, and also more aesthetically pleasing to construct the final product out of bamboo wood. Since there was already spare bamboo, no materials needed to be purchased and all the attachment methods were done using supplies the school already had, resulting in the excess of funding.

2.8.1 Full Scale Prototyping

Now that I have more information on important things to note, such as size requirements, materials and mechanisms, I can now build a full scale prototype. This prototype will be made out of plywood which is a cheap, easy to use material that I can use to determine the final sizes of metal that I will need for the final product. In addition, I can also use it to determine if any measurements, such as distances in between mounts need to be changed. Building the final prototype can be divided into 3 parts. The first being producing the rails, the second the frame, and the third being the assembly of the stand.

Phase 1 - Rails

To make the rails for the prototype I knew I wanted to make them using dowel as it is a material I have used before, however the problem of size came into play very quickly. I looked at various sizes with several teachers and came to the conclusion that if I were to use a size with a similar diameter to that of which I intended to make using steel for the final product, the wooden dowel would be too flimsy. As a result, I decided to use a length of dowel with a diameter of 25mm.

Next I marked out the predetermined lengths I would need for the rails on the dowel, incorporating buffer zones for cutting in order to ensure I had the right length of dowel for the part. When it came to cutting the dowel, my plan was to cut the corners of the lengths of the dowel at 45 degree angles to form mitre joints at 90 degree angles, however consultation with a teacher with technical experience changed that idea. Instead, we came to the conclusion that the sides of the rails did not need to be cylindrical, and instead could be flat pieces of wood with screws. This not only makes the process easier, but also makes the structure stronger, and as a result, cutting was delayed to allow time for adjustments.

Phase 2 - Frame

The second phase of construction was creating the frame, and this yielded several challenges. The first notable obstacle was structural integrity. In order to conserve materials I decided to use cardboard as a building material, which turned out to be a bit of a mistake. The cardboard was too flimsy to support itself and the rails, let alone 5 guitars, so as a result I made the decision to make the frame out of plywood since the school had plenty of spare. This resulted in more changes being made. Instead of bearings I

Figure 47: bolts joining rails to the frame

used bolts and screws to create an axle that the rails could rotate around as shown in figure 30.

In addition to this, I also added velcro strips to all surfaces that come into contact with any part of the guitar. This is merely a temporary measure, and will be replaced by rubber sheeting which is more effective and used on other guitar stands on the market. The velcro strips are there so I can rest my guitar on it to check that the measurements are right.

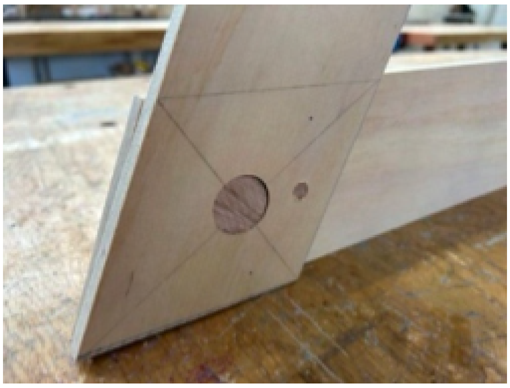


Figure 48: Leg fastening system

There was also another change made to the design, that being the leg joints. The original Idea was to have the legs on the inside to save space, however the width of the wood for the prototype and the metal for the final product is negligible, meaning I have put the legs on the outside of the frame, which allows for a different locking mechanism. Again, the original idea was to use locking table brackets, however there is not enough space in between the leg and the frame for such a mechanism to be placed.

As a result, with consultation with the school's technician, we determined that a push/pull pin system would be better to lock the legs in place. A basic version of the system is shown in figure 31, in which a small piece of dowel is inserted into a hole in each piece of wood to lock the leg in place. There is a second hole in the frame so the same can be done when the leg is folded down.

Phase 3 - Assembly

The third and final phase of construction was bringing all the pieces together to form the finished product. To assemble the frame I used metal brackets to join the side parts and the neck holders together using screws as shown in figure 32. Whilst there were only the two brackets joining each side together, I originally intended to have some dowel joints to fasten it as well, however that proved unnecessary.

Figure 49: metal brackets joining the frame

Having assembled the frame I discovered that the stand is actually stronger than I originally thought. I had fears that it would not be able to support its own weight. I noticed that there was a bit of lateral flex in the frame, indicating that whilst the 4 brackets were enough, more could be done, with possible solutions being extra reinforcement with dowel and wood glue or increasing the thickness of the wooden parts. Furthermore, the very rushed method of ‘fixing’ the legs to the brackets in Figure 34 resulted in some sideways swaying.

Nevertheless, it held strong and I was able to place one of my guitars on it. In terms of measurements, the only part that needed correcting was the thickness of the neck holders, which was slightly shorter than the width of the side frames, and the rails turned out to be sitting a little high. Everything else worked fine, with the guitar being able to be placed on the stand with little to no difficulty, and being able to stay there comfortably without being moved around by gravity or the frame breaking.

2.8.2 Evaluation of the Full Scale Prototype

Analysis of this prototype indicates that there is merit to the design as it is capable of holding multiple guitars at once. As stated before I was concerned about the structural integrity of the prototype due to the sketchy leg joints but even with a small degree of leaning the stand was able to hold more than one guitar. I have been able to test it with a Flying V, Gibson, Ibanez and even a bass guitar and all of them were able to be placed on the stand. Furthermore, the measurements for the dimensions and so on are good, as everything fits, however, I discovered that the rails were actually mounted quite high, as there is now an excess of space beneath the guitars, and this then results in the necks extending quite high. Whilst the stand was able to support 2 guitars, I feel that if I lower the rails enough so that the necks don’t extend too much past the top of the stand, but still keep it high enough that I can place any type of guitar on it, then it would lower the centre of gravity, making the stand a lot more stable to use.

Figure 50: finished prototype successfully holding a guitar

There are also a number of other things that should be noted with this design. The use of velcro strips is temporary, so the wood doesn't scratch the guitars when placed on the stand for testing purposes. This velcro had very little friction, and as a result, some of the guitars slid sideways a little. Using proper rubber with a higher degree of friction should solve the problem. In addition, the leg joints need work if they are to fold up effectively. Using a push pin will allow for the user to easily fold up and lock the legs into place. The bolts used to fasten the rails to the frame also interfered with the legs, as despite chiselling out some wood to make the bolts fit in flush with the frame, there was still a portion of the bolt with a curved head sticking out, which would prevent the legs from folding up, so using bearings that can fit flush with the frame should help. The legs on this model cannot fold up as a result of the above reasons and the availability of materials at the time, meaning this will need to be addressed for the final model.

The joints at the top of the frame that secured the neck holders to the side frames were good at their job, however the thickness of the wood was a problem, as there was not much there to prevent lateral swaying. I originally intended this stand to be made of metal, however seeing a wooden prototype has made me think if wood would be a better choice, since it is easier to work with and can be treated to make it look polished and refined. As a result, I will be using a thicker bamboo sheet of wood that I can CNC cut to ensure a higher degree of accuracy.

Ongoing Evaluations: The process of making the full scale prototype worked well in not only testing to see if the measurements were suitable for housing a guitar, but also to see how the process of putting it together would go. Overall the stand was able to hold the weight of at least 2 guitars at a time. However, the main purpose was to see if the design could work for holding the guitars and to test the measurements, and as a result, the folding leg mechanisms were not incorporated. This will result in me having to figure out a solution as to how I can actually attach the intended mechanisms to the design whilst I am building it, potentially leading to a decrease in quality

2.9 Construction of the Final Design

Construction began by creating the Adobe Illustrator file to be used for CNC routing the frame. The CNC router would allow a higher degree of precision when cutting while also increasing the efficiency and speed of the process. It will also allow cutting of a thicker wood to increase the strength of the frame. The red lines indicate where the drill will cut, and the black infill represents where the drill will etch in. This is because the regions in which the etching will occur is where bolts will go to fasten everything together. By etching in where those locations are, it saves time and effort having to manually mark out where everything needs to go, and also reduces the potential for errors in the construction.

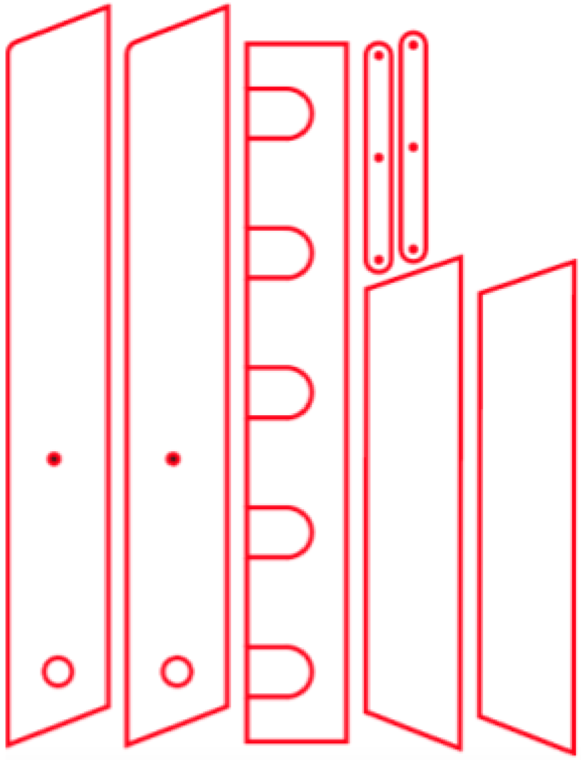


Figure 51: Adobe File

Figure 52: Bamboo wood with maple stain (top) and cedar (bottom)

The next step involved correcting some measurements, as two of the pieces were 70mm short. After correcting this issue, it took some time to wait for the CNC router to be free. During this time sanding of the wood took place. In order for someone to pick up the stand and not slice their hands on any sharp surfaces. Using the roughest sandpaper the workshop had, I sanded off any flakes of wood missed by the CNC router and rounded off the edges so they were smooth. After that the surfaces were sanded working from the roughest to the smoothest sandpapers available. After reaching the smoothest sandpaper, I went over again using regular paper to really smooth out all the edges.

After sanding the wood, given that there were 2 spare pieces of wood, I decided to test various wood stains on them to see if they enhanced the aesthetic look of the wood. The bamboo itself looks nice but a lighter or darker stain might be more appealing.

The two stains tested were cedar and maple, which provide a very different colour to the standard bamboo. Whilst the two colours are nice, I personally prefer the colour of the bamboo, especially once the wood has been sanded.

At this stage I was ready to assemble the frame, and started with the rails to hold the base of the guitars. This process was rather simple, and just involved drilling screws into the side pieces to attach the dowel to form a rectangular structure

Figure 53: Rails under construction

With the rails built the time came to assemble the side frames, however this highlighted the fact that the method intended to fasten the legs might not work. The original intention was to use a bearing, however with the prototype the use of a length of dowel and a central bolt going through proved sufficient. As a result, the side frames and the legs needed to be re-cut to incorporate indents where the dowel will go, and also solved the problem of one of the original side frames not being mirrored correctly.

This led to the discovery of another problem, that being that the spring plungers ordered to lock the legs in place were too small and consequently too weak to hold the legs in place. The figure 40 shows the results of preliminary strength testing by applying force using my hands, and the wood breaks fairly easily, along with the metal plunger breaking.

Figure 54: failed spring plunger, the plunger was too small and consequently too weak to stop movement of the two pieces on a demo that was made.

Consequently, during the post mortem on the spring plungers, I fastened the foam onto the rails using a brush adhesive, in which adhesive is applied to both the foam padding and the rails and left to dry. After the two pieces are applied and very quickly they become stuck together. The method is strong but also durable, meaning any sliding of guitars, placement and other wear and tear will be minimised.

However, due to the strong nature of the adhesive, if applied incorrectly the joint is irreversible. During the application a part of the foam padding accidentally made contact with the rails before the padding was aligned properly. Damage was minimised by continuing the application in a manner that resulted in the foam padding spiralling slightly around the rails. In addition, due to the way the foam was cut, the roll was not wide enough to cover the whole rail, so 4 pieces were needed to get everything. I then went and applied a second layer to cover up the gaps.

Figure 55: Image of new layer of padding around rails.

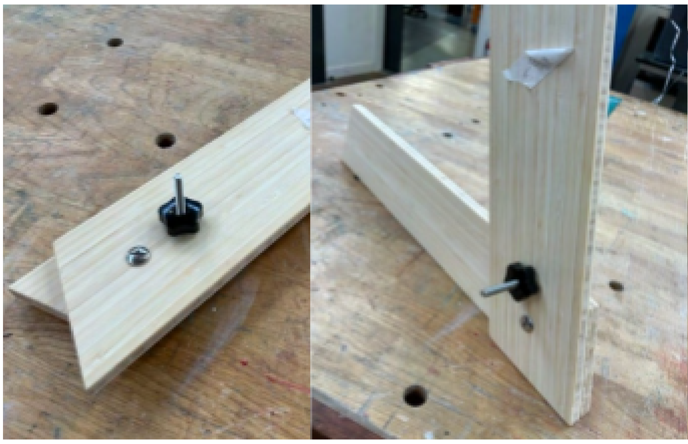


Figure 56: locking pins holding the leg folded down (left) and extended (right)

Figure 57: Padding on the neck brace

The solution to the locking pins problem ended up being a bolt with a screw end, and a knob that fits on the other end being used to tighten the screw, locking the legs in place. This is slightly more time consuming to operate than intended but the time constraints mean the simple yet effective method with relatively little changes needed to the existing design is welcomed.

The next step was to add a layer of padding to the neck slots so that the guitar's neck is not damaged when placed on the rack. This used the same method that was used to apply the padding to the rails. Contact adhesive was applied to both the padding strips and the areas of the neck brace that they would come into contact with, and then the two parts were joined. This had little errors in the process leading to 4 out of the 5 slots looking rather clean, with only one of the slots having a bit of excess adhesive that needed to be wiped away.

Now that all the parts were completed, I was able to join the entire frame together to form the guitar stand. The first step was fitting the screws that joined the side frames to the neck brace. This proved to have some difficulty as 2 of the pilot holes for the screws were too short, and consequently had to be re-drilled, however this proved to be rather simple to fix. Once the two pieces were joined together, the other side frame was screwed in.

Once the side frames were attached, the rails were placed in their location, with 2 bolts going through the sides with counter synced nuts locking them in place, whilst still allowing both the rails to rotate and the legs to flip up into the more compact solution. As a result the stand was complete, and this time able to fold down into a more space efficient solution.

Figure 58: Images of the final product

Figure 59: Images of the final product with the legs and rails in the more compact storage form

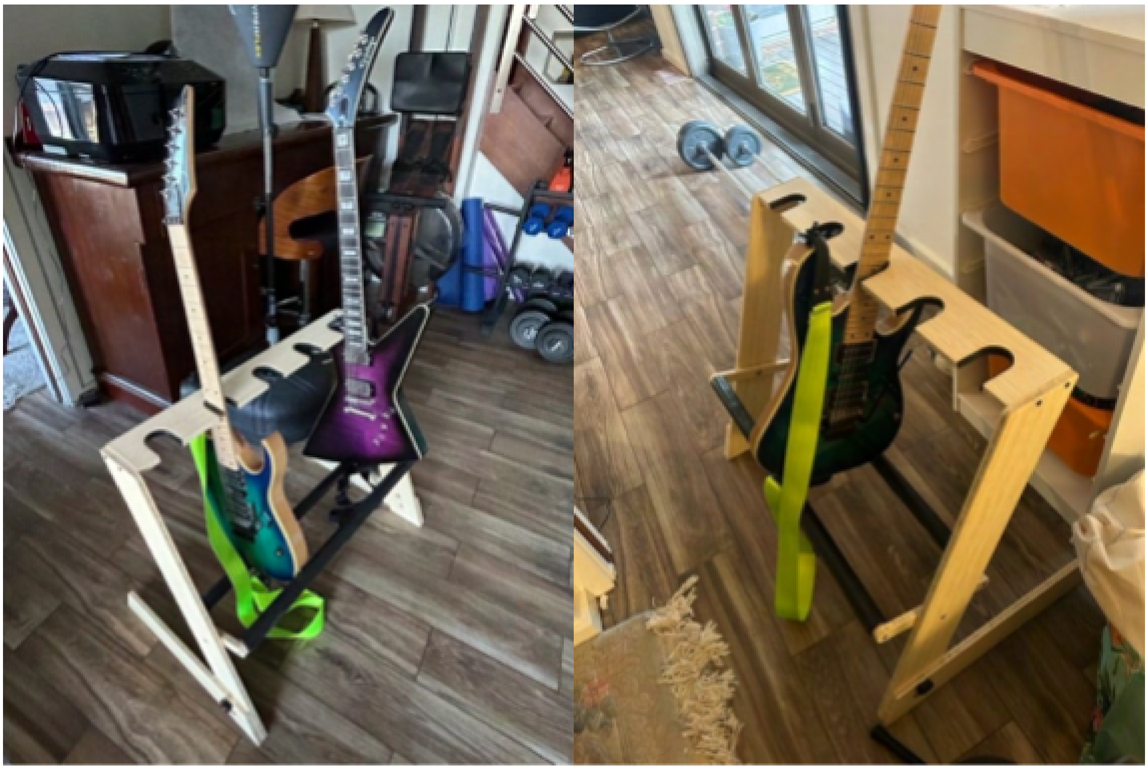


Figure 60: Images of the final product holding 2 guitars, an Ibanez (green) and an explorer (purple)

3.1 Final Evaluations

Restatement of Intentions

With this project I plan to design a guitar stand that can solve the problem of space efficiency along with guitar compatibility. As a result of brainstorming, researching and surveying I have found that there is a genuine need for a guitar stand that can accommodate multiple guitars of varying shapes and sizes, as well as fold into a more space efficient form for transport. As such the stand will be designed to hold several guitars and be able to fold down flat for ease of transport.

3.2 Evaluation Using the Criteria for Success

Using the criteria for success on page 19-20 it is possible to determine if this product is a success or not. The first criteria listed is the ability for the stand to hold 5 or at least 5 guitars. Upon testing the stand at home with some of my guitars, I discovered that the stand was unable to hold some shapes of guitars when the explorer was placed on the stand first. This was due to the fact that the explorer rotates the rails as it needs to, however this then means that the rails are now at a funny angle (*figure 46, left*). As a result, the other guitars are sitting too high and the neck brace ends up being positioned where the end of the body is, which is too thick and consequently cannot fit in the designated slots.

The cause of this problem is most likely due to the height of the stand. During the construction of the final design when I encountered the problems with the side frames not being mirrored correctly, I must have misread a file name and opened the wrong file where the dimensions were too short, then corrected those instead of the longer ones. This led to the side frames being too short even though the prototype was correct. That being said, the stand does have 5 slots, so it technically succeeds in this regard.

The second criteria is for the guitar stand to be able to fold down into a more storage efficient form. Despite the fiddly method of locking the legs (a method I would change if I were to do this again) the legs are still able to fold flat, and the nature of the pins means that the legs are able to lock in place when flat, meaning that nothing will move about. Furthermore, the rails can rotate flat meaning the whole thing becomes flat, with the height going from over 700mm to just over 100mm, which greatly reduces its profile (*figure 45*) and makes it easier to store, making the stand successful in that area.

The next criteria listed is the ability of the stand to hold multiple shapes of guitar. Due to my error that led to the stand being too short, it cannot fit a flying V, explorer or regular shaped guitars all at the same time, despite attempts to place one on the stand. If the side frames were higher by about 10 cm then there would be enough space to counteract the guitars being placed at a higher position due to the angle of the rails, alas that is not the case. However, the minimum requirement was for the stand to be able to at least hold the ‘normal’ guitar shapes such as a Fender, Ibanez or Gibson, which are all fairly similar. Figure 46 (left) shows the stand comfortably holding an Ibanez, as the rails are not at an odd angle due to the relatively flat base of the guitar body. This results in the guitars being housed low enough for the neck brace to be able to function properly, and as such the stand could hold multiple guitars if they were of the ‘normal’ shape, thus meeting the minimum requirements.

The final criteria listed is environmental friendliness, specifically the ability for components to be recycled. The wood is recyclable and renewable, the metal bolts can also be repurposed or recycled and the foam padding is also recyclable. The only part of the stand that would be difficult to achieve this with would be the wooden dowels and the neck brace on which foam padding is fixed to, as the contact adhesive is unable to be recycled. Furthermore, the only glue used was the contact adhesive, meaning all the bolts, screws and separate pieces of wood can be disassembled and salvaged. As a result, the stand is not 100% recyclable, but all but one of the components (the contact adhesive) are eco friendly, meaning the stand meets the minimum requirements in this field.

Overall I would say that the stand is not a total failure. Whilst it failed to do one of the most important tasks I set out to achieve, the stand functions as a proof of concept. The prototypes and subsequent documentation show that there is merit to the design, and that if I hadn’t made an error in the Adobe files, the stand would be able to achieve its purpose in full. Despite the failure, the stand still meets the minimum requirements of being able to house 5 guitars, be environmentally friendly and holding at least normal guitars, along with succeeding to fold down flat.

Additional Considerations

Whilst it was not listed on the criteria for success, one respondent in the survey took note of the aesthetics of guitar stands and how they are not very appealing. This design does sport the sleek minimalistic design, however due to time constraints, some aspects of this suffered. There are a few small spots with some excess contact adhesive that were not wiped away properly, making the stand look rushed and unrefined in some sections. Furthermore, after looking at the completed design, I noticed the distinct contrast between the bamboo wood and the black foam padding. The contrast doesn’t blend well and as such if the stand was painted black it would hide the padding more, potentially adding to the aesthetic value. However, all things considered it still retains most of the aesthetic appeal.

Another area of concern I spotted when testing was the angle of the neck brace when paired with the thickness of the padding. The neck brace is level with the floor, but the guitar is on an angle. This results in the weight of the guitar's neck being placed on the corner of the foam strip, which has less structure and consequently is pressed in more. This led to the foam coming in contact with one of the strings of the guitar, and if left for extended periods of time, the foam could even wear away leaving no padding between the brave and the guitar.

Solutions to this problem can be found in changing the angle of the neck brace so it is parallel to the angle of the guitar, however this could prompt issues if the stand was built correctly and was able to house multiple shapes of guitar, in which case some guitars may sit at different angles to others. Another solution could be increasing the thickness of the padding by adding another liker like I did with the rails. However this would reduce the amount of space there is in the slots, and so consequently the neck brace would need to have its slots widened accordingly.

When putting multiple guitars on the stand I also noticed a small degree of lateral swaying from side to side. I saw this problem in the full scale prototype and attempted to fix this for the final product by using screws that went through both pieces of wood instead of the metal brackets, however that did not seem to fix the solution. Whilst the swaying is not game breaking, as it can still hold the guitars and the only problem would be if the client lives in an earthquake prone region, the movement could be improved in future iterations. Adding a structure such as an A frame brace, another plank going across the bottom or a combination of the two could result in reducing the swaying.

Another problem was the consideration of the results of the survey I conducted. I paid attention to the fact that people needed a better form of storage that can be space efficient and hold multiple guitars, however after specifically mentioning the need for the capacity to store an explorer, I completely failed to address that issue. At no point in the process did I consider ways to store an explorer, only normal guitars and flying Vs, which is in part why the stand does not accommodate explorers well. My failure to address this need led to the partial failure of the project and thus in future projects will need to be rectified.

Another issue was completely missing the fact that many people have acoustic guitars as well. 66.7% of respondents to the survey said they had both acoustic and electric guitars, meaning if I had accounted for the measurements of acoustic guitars and made changes accordingly to accommodate acoustics on the stand, the final product would be able to serve a wider community.

3.3 Evaluations on the Individual, Society and Environment

Individual

The impact of this product in the individual is moderate. The product failed to meet the desired goals but did manage to meet the minimum requirements, and can serve as a proof of concept. In its current state however the stand can hold regular guitars, meaning it can save space in both their music spaces and benefit some people who have many normal guitars that need to go places. Given the ability to fold flat it can also benefit those who need space efficiency, making the stand somewhat useful but not to the extent that was intended at the start of the project.

Society

Whilst this product did not achieve everything it wanted to, it can still affect society in a positive way. Groups of musicians tight on space can use this stand to store all their regular guitars and cut down on space, leaving greater room for the communal rehearsal space. It can also make the lives of many musicians easier and also in transit. Many young musicians starting out will need to be efficient with their cargo space when transporting equipment when moving between venues as they won’t have the money to acquire large transport vehicles. The flat nature of the stand means that it can be lined up against a wall without taking up too much space, allowing for more instruments and equipment to be put in the same space.

Environment

The environmental impact that this product has is neither deleterious or beneficial. The product does not seek to improve the current state of the environment as it is a guitar stand, meaning the production of this product has not reduced pollution or cut down on emissions of any kind. However, the stand is not deleterious to the environment either, as once the product reaches the end of its lifecycle, all the components can be either recycled or made of renewable resources. The plywood used can be regrown, the metal bolts, washers and screws can be recycled and the foam is also recyclable, meaning that none of the components - if disposed of correctly - will end up contributing to the pollution that plagues this planet.

Reference List

(n.d.). Mega Music Online – Buy Musical Instruments Online at Mega Music. Retrieved November 24, 2022, from http://megamusiconline.com.au

(n.d.). Musical Instruments & Pro Audio // Mannys Music. Retrieved November 24, 2022, from http://mannys.com.au

Allwood Stands. (n.d.). Custom Guitar Stands | AllwoodStands. Retrieved November 24, 2022, from https://www.allwoodstands.com/

Aluminium 6000 Series Information Guide. (n.d.). 1st Choice Metals. Retrieved February 14, 2023, from https://www.1stchoicemetals.co.uk/aluminium/grades-guide/6000-series/?doing_wp_cron=1676327003.2050840854644775390625

Arzt, K., & guide, s. (2022, March 28). *What is Metalworking? Beginners Guide To Working With Metal*. The Crucible. Retrieved February 22, 2023, from https://www.thecrucible.org/guides/metalworking/

Binyamini, Y. (n.d.). *Your Guide to Build and Shape a Stratocaster Body*. Electric guitar lutherie, DIY, repair and maintenance. Retrieved February 6, 2023, from https://theelectricluthier.com/your-guide-to-build-and-shape-a-stratocaster-body/

Carlson, M. (2016, March 2). *Musician's Guide To Music Instrument And Equipment Storage*. Clutter. Retrieved November 24, 2022, from https://www.clutter.com/blog/posts/music-instrument-equipment-storage/

CSC 297 Robot Construction: Joints. (n.d.). Department of Computer Science : University of Rochester. Retrieved March 9, 2023, from https://www.cs.rochester.edu/u/nelson/courses/csc_robocon/robot_manual/joints.html

Different Grades of Aluminum and Their Applications. (2021, June 15). Thin Metal Sales. Retrieved February 14, 2023, from https://www.thinmetalsales.com/blog/different-grades-of-aluminum-and-their-applications/

Foam Types - Definitions, Qualities and Common Uses. (n.d.). FoamOnline. Retrieved February 17, 2023, from https://foamonline.com/foam-types/

4 Different Types of Welding Processes 2023 - NEIT. (2020, August 16). New England Institute of Technology. Retrieved February 23, 2023, from https://www.neit.edu/blog/types-of-welding-processes

Gator Cases. (n.d.). Gator Cases. Retrieved November 24, 2022, from http://gatorcases.com

Gibson Les Paul guitar: price, review and opinions. (n.d.). Culturasonora. Retrieved February 6, 2023, from https://www.culturasonora.es/en/musical-instruments/gibson-guitars/les-paul/

Gibson SG Standard Solid Body Electric Guitar (1969) | *RetroFret*. (n.d.). RetroFret Vintage Guitars. Retrieved February 7, 2023, from https://retrofret.com/product.asp?ProductID=8259

Heather. (n.d.). *Thick vs Thin Guitar Neck: Which is Best for You?* Pro Sound HQ. Retrieved February 7, 2023, from https://prosoundhq.com/thick-vs-thin-guitar-neck-which-is-best-for-you/

Janka Hardness. (n.d.). The Wood Database. Retrieved February 10, 2023, from https://www.wood-database.com/wood-articles/janka-hardness/

Morton, D. H. (n.d.). *EP1044630A1 - Folding table leg brace mechanism*. Google Patents. Retrieved March 17, 2023, from https://patents.google.com/patent/EP1044630A1/en

Owens, J. (n.d.). *4 Guitar Storage Tips | How to Store Your Guitar*. Fender. Retrieved November 24, 2022, from https://www.fender.com/articles/tech-talk/case-closed-storage-tips-to-save-your-guitars

Properties and Production of Lightweight Metals. (2016, October 6). AZoM. Retrieved February 13, 2023, from https://www.azom.com/article.aspx?ArticleID=13063

Ranj, B. (n.d.). *Best Folding Guitar Stands 2020*. Rolling Stone – Music, Film, TV and Political News Coverage. Retrieved November 24, 2022, from http://rollingstone.com

Stoneybrook, J. (2022, February 14). *Keep Your Instrument Safe With the Best Guitar Stand – American Songwriter*. American Songwriter. Retrieved February 9, 2023, from https://americansongwriter.com/gear-guides/guitar-stand/

10 Best Guitar Stands for Stage or Personal Use [2022 Edition]. (2022, November 3). Guitar Space. Retrieved November 24, 2022, from https://guitarspace.org/guitar-accessories/the-best-guitar-stands-on-the-market-today/

Top 10 Hardest Woods in The World. (2022, September 9). Hitchcock & King. Retrieved February 10, 2023, from https://www.hitchcockandking.co.uk/h-k-news/top-10-hardest-woods-world/

Types and Applications of Industrial Rubber Sheeting. (n.d.). The CSI Knowledge Base. Retrieved February 21, 2023, from https://knowledgebase.csi-products.co.uk/industrial-rubber-sheeting/

Welding Joint Types: Butt, Lap, Tee, Edge Joints & More | UTI. (2020, September 2). Universal Technical Institute. Retrieved February 23, 2023, from https://www.uti.edu/blog/welding/joint-types

What Happens When Wood Floors Get Wet? - Escarosa. (n.d.). Escarosa Cleaning & Restoration, LLC. Retrieved February 10, 2023, from https://escarosacleaningandrestoration.com/what-happens-when-wood-floors-get-wet/

What is a ball bearing and where are they used? (n.d.). Acorn Industrial Services. Retrieved March 14, 2023, from https://www.acorn-ind.co.uk/bearings/ball-bearings/details/