Criterion A

1. Design Opportunity (200 words)

Because most people live in cities, today's society has a shortage of space. People who work in confined spaces use desk lamps that take up a lot of room and prevent them from having a productive workplace. Working in such a confined space causes stress and lowers productivity.

People spend 90% of their time indoors (Tristan Roberts, 2016), with much of those hours at work. To maximise productivity, workspaces must be both functional and visually appealing. The following are work environment characteristics that negatively impact productivity (CMD researchers, 2022):

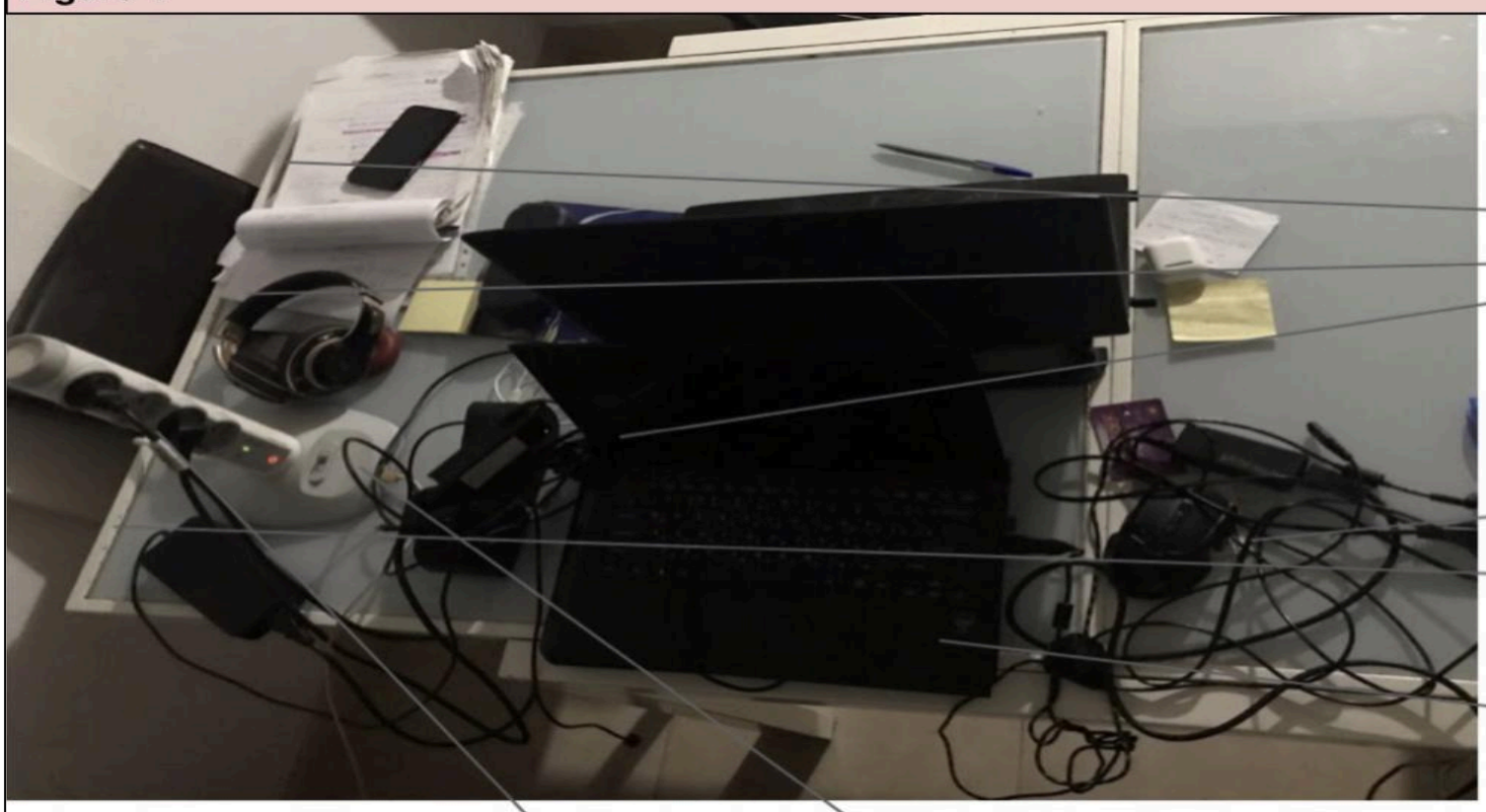
Insufficient lighting	34.7%
Untidy workstation	29.4%
Visual untidiness (eg: trailing wires)	15.1%
Lack of available plug sockets near the desk	11.5%
Lack of phone charging options near the desk	7.4%

My design goal is to address these major issues that impairs productivity by developing an innovative desk lamp (F2.1)

Insufficient Lighting Problem (F2.3)
Integrating luminants that mimic natural light will be used to relieve light insufficiency. Enabling the building's circadian cycle to be changed during the day, hence, reducing interruptions to circadian rhythms and sleep cycles. This will help the person reduce headaches/fatigue (Hedge et al., 1989) and improve sleep quality (Jon Richardson, 2019).

Workspace Untidiness Problem (F2.2)
People heavily rely on electricity-dependent technology and rooms often lack sufficient charging hubs. Hence, usage of charging extensions will take up even more space. Furthermore, often plugs are placed in inconvenient places resulting in charging cables covering entire desks, increasing workspace clutter. USB port hub integration in lamp will reduce need of extensions, therefore improving user comfort by providing conveniently situated ports.

Figure 1



Tidy workspaces benefits

Article
"Working in a clean and tidy working environment means you are less likely to be distracted by objects cluttering up a workspace, hence clean offices can lead to increased focus" (Sourav Basak, 2022)

Article
"Less time wasted searching for important documents, a tidy, well-organized office leads to a more productive day. In fact, searching for lost documents equates to businesses losing around $2.5 million in lack of productivity, according to data by the International Data Corporation." (Gabrielle Pickard-Whitehead, 2018)

Article
"The average person wastes 4.3 hours per week searching for paper, which increases stress and reduces concentration and creative thinking." (Pat Heydlauff, 2022)

- Tidy workspaces aids reduction in user distraction and stress
- Consequently, users are more concentrated and focused on the work
- - Greatly aiding user's productivity and work efficiency
- - Increasing user's ability to be creative and imaginative
- Consequently, firms will benefit from reduced financial losses

Messy workspaces problems

Publication
"In an increasingly paperless world, a spaghetti junction of tangled, trailing wires is often the main culprit for creating unsightly clutter in an office. This is down to the fact that desks are generally laden with a combination of computers, keyboards, laptops, phones and tablets." (CMD researchers, 2022)

Article
"We've found that people sitting at messy desks are less efficient, less persistent, and more frustrated and weary than those at neat desks." (Boyoun (Grace) Chae et. al., 2015)

- Excess trailing cables will cause workspace clutter
- Increased technology adoption results in greater quantity of charging cables covering desks
- Leading to increased frustration and stress resulting in productivity deterioration

Insufficient lighting problems

Publication
"Spending too much time in dimly lit rooms and offices may actually change the brain's structure and hurt one's ability to remember and learn" (Andy Henion, 2018)

Publication
"It's no secret that dim lighting can strain the eyes and cause headaches, lowering productivity and resulting in employee fatigue" (Jeff Pochepan, 2017)

Publication
"Poor lighting contributes to inadequate sleep, drowsiness, fatigue, stress, anxiety and even seasonal affective disorder. It significantly affects your mood, happiness, concentration and other cognitive functions like disengagement" (Light Research Centre, 2017)

- Poor learning productivity
- If the user isn't working comfortably, he isn't working smart
- If user isn't working smart, he isn't working to his full potential
- Hence, discomfort will cause poor sleep and fatigue leading to low productivity

2. User Research

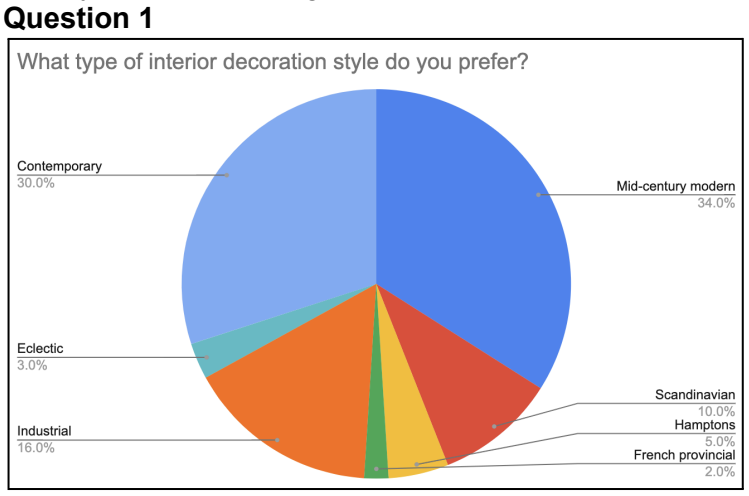
Client profile (F2.1)

Characteristic	Explanation
Age	Students ageing between 15-25
	Adult professionals ageing between 25-40
Activity	Often spends time studying/working
	Often studies/works during night times in dark environments
Status	Works at constrained and messy workspaces due to cluttering of goods

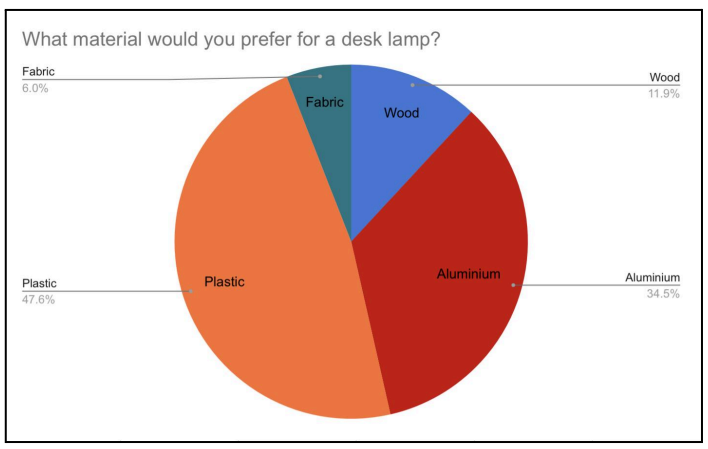
User primary research (survey of the 48 people of target audience)

Survey of 48 people to gather information about current needs of consumers and identify the market gap to ascertain high demand of the product.

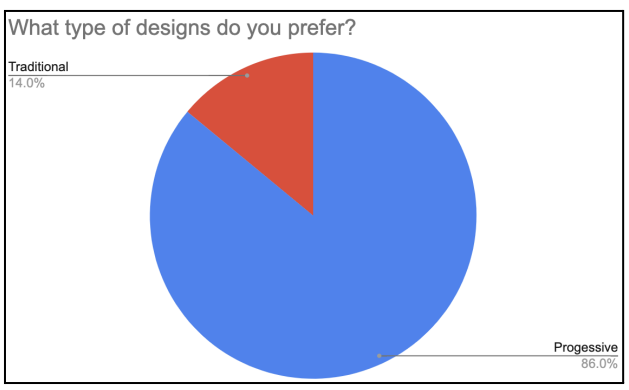
Question 1



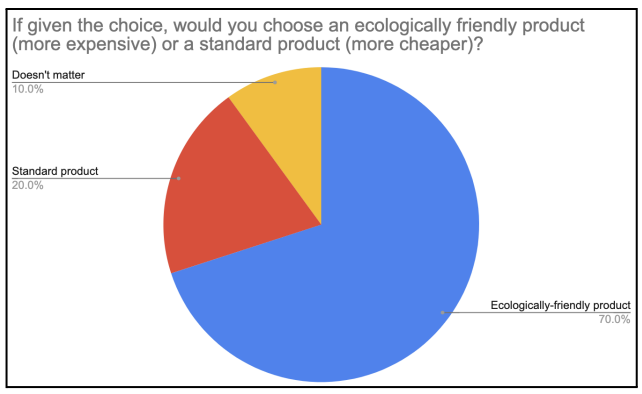
Question 2



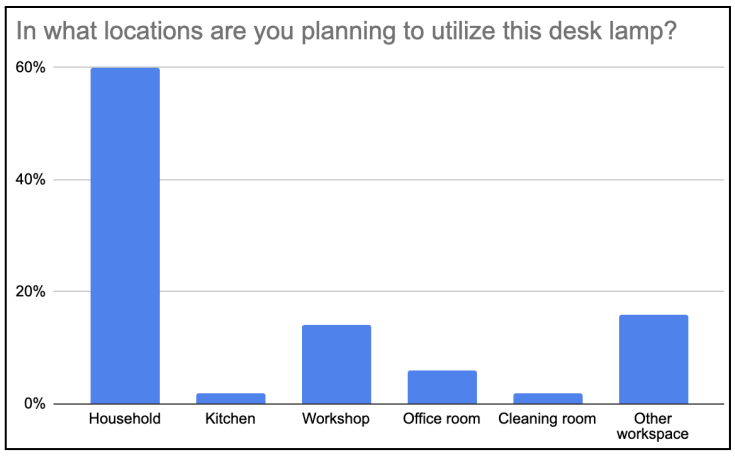
Question 3



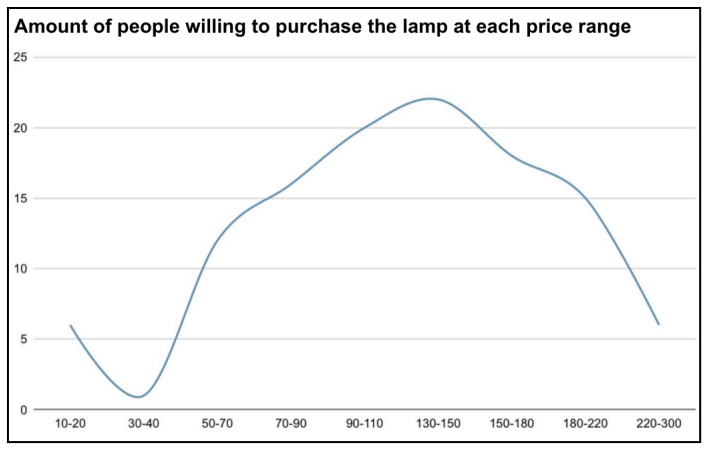
Question 4



Question 5



Question 6



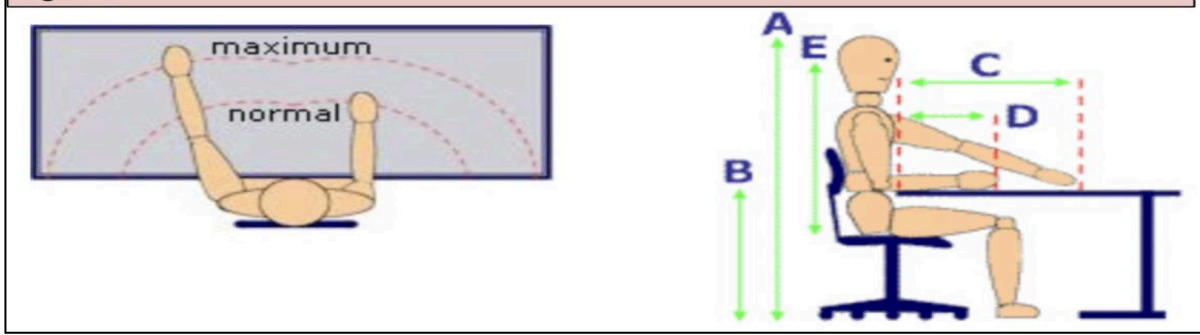
Conclusions drawn from the survey

Requirements	Conclusion
Aesthetic requirements (Questions 1, 2, 3):	**Q1** (F1.1)**.** 57% of respondents prefer contemporary styled products
	Indicating that product aesthetics must be modern
	Q2 (F4.1)**.** 47% prefer plastic, followed by aluminium with 34%
	Because many designer lamps are made of aluminium, I anticipated it to receive a high score.
	Nevertheless, this demonstrates that the industry may not be able to meet the requirements of consumers.
	Q3. Consumers prefer progressive design
	Meaning that even though industry is dominated by traditional design, people are generally open minded about innovative products
Environmental requirements (Question 4):	**Q4** (F4.2)**.** 70% of respondents indicated they would choose an ecologically friendly product over a standard one if given the choice, regardless of the increased price for an ecologically friendly product.
	Respondents also indicated that products should be manufactured from recycled or recyclable materials (e.g.PLA, ABS) to minimise its carbon footprint.
	I need to utilise the fewest materials and generate the least amount of waste possible
	To avoid causing environmental damage and make it easier to replace broken components.
Safety requirements (Question 5):	**Q5** (F1.2)**.** Key point in the safety of utilising the product is having no sharp edges and having all electronics completely unexposed to user's direct access.
	It is important because 60% of respondents plan to utilise the products in their households.
	Making it likely to present around them even when not used
	It can also be exposed to other residents of any age and health conditions.
Cost requirements (Question 6):	**Q6** (F3.1)**.** People would spend between 60-200$ on a new desk lamp
	Few would spend more than 200$, hence there is a clear limit on how much the product can retail for.
	Therefore, I should aim for a material cost of roughly 1/3 of the retail price, approximately $30.

Secondary research

Anthropometric data for Spanish adults 16-65 years (cm)			
Dimension	5th %centile	50th %centile	95th %centile
Shoulder-grip length (maximum working limit)	61	66.5	73.5
	55.5	60	71.5
Elbow-fingertip length (normal working limit)	44	47.5	51
	40	43	46

Figure 2



Primary research (static measurements of human body parts)

Figure 5

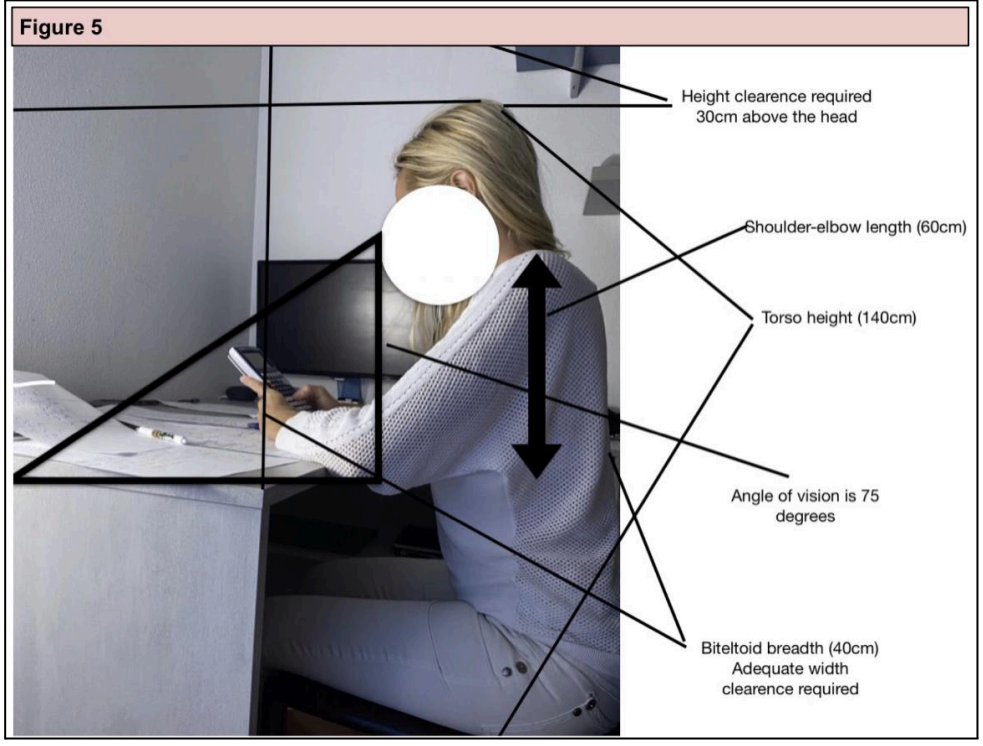


Figure 3

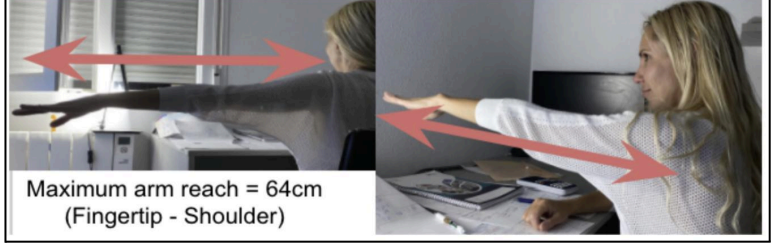


Figure 4

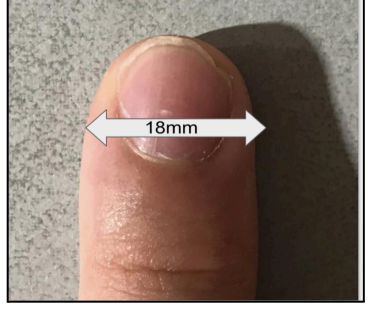


Figure 6

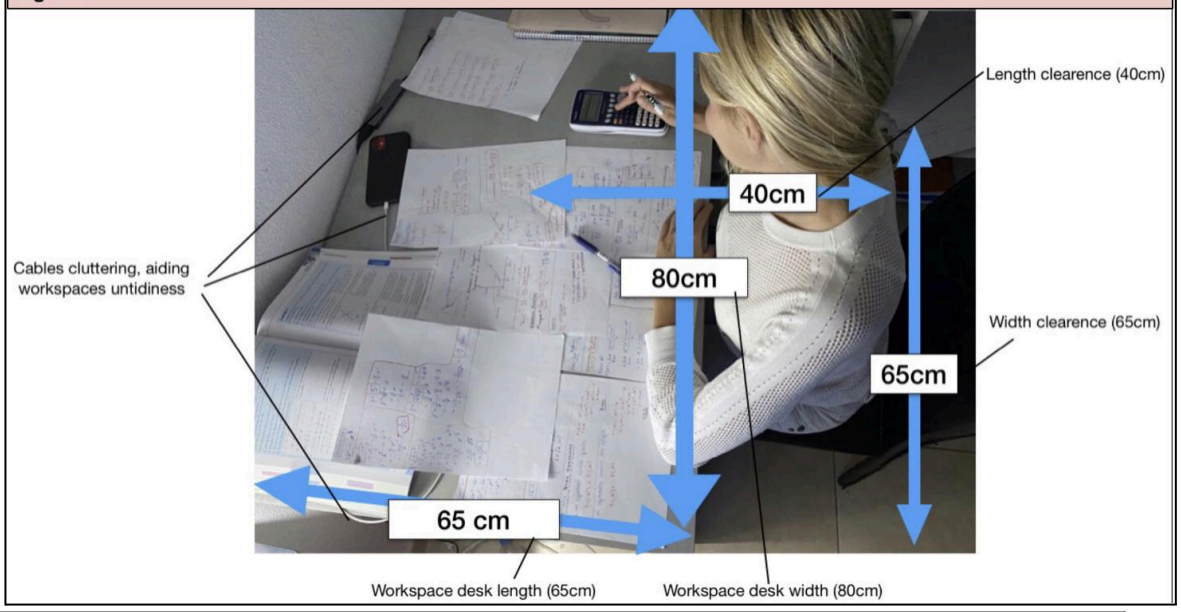
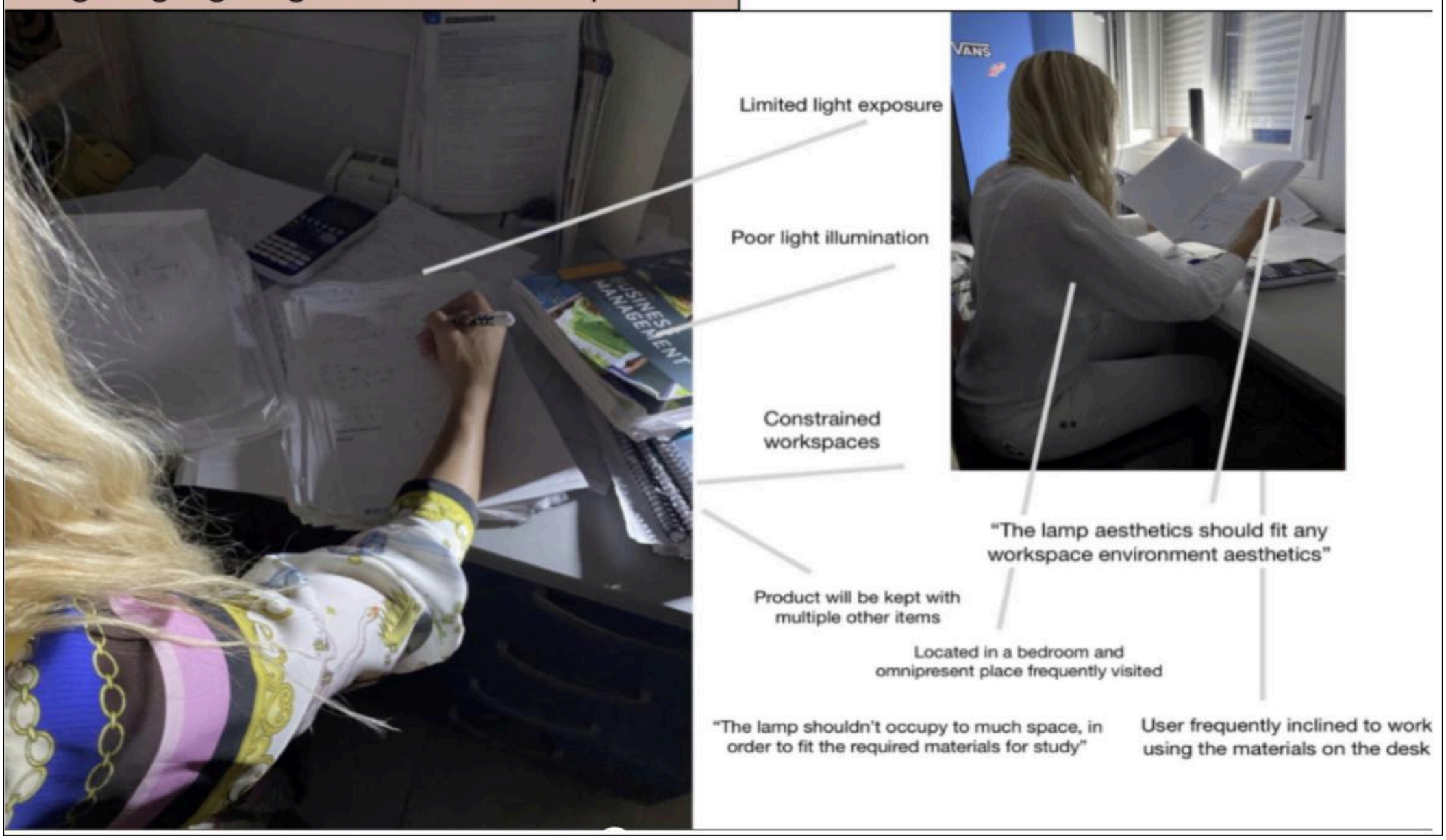
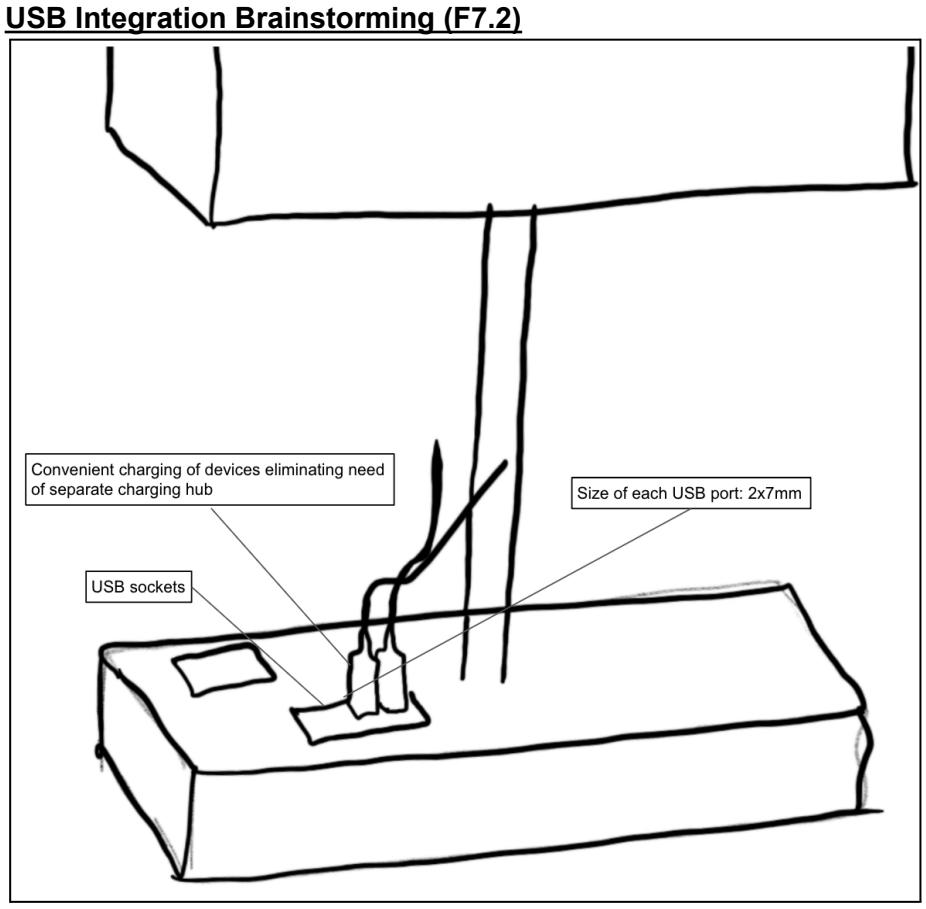


Figure 7

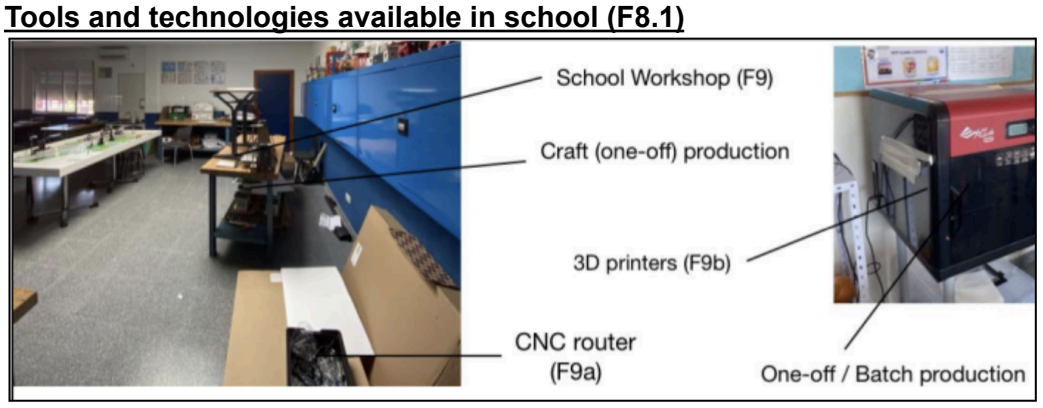
Image highlighting user's need and problem



USB Integration Brainstorming (F7.2)



Tools and technologies available in school (F8.1)



Light Sources Research (Brandon McBride, 2021)

	Fluorescent bulbs	Incandescent bulbs	Light emitting diodes (LEDs)
Image			
How it works	Tungsten filament heated to 2,200 degree Celsius	Heated gas produces ultraviolet light converted to visible light by bulb coating	Solid-state light-emitting diodes
Cost per bulb	$ 0,50	$ 4,00	$ 25,00
Lifespan	1,000 hours	8,500 hours	25,000 hours
Number of 60-watt equivalent bulbs required to supply 20 million lumen-hours	22	3	1
Equivalent brightness:			
- 2,600 lumens	150 watts	32-35 watts	25-28 watts
- 1,600 lumens	100 watts	23-26 watts	16-20 watts
- 1,100 lumens	75 watts	18-22 watts	13+ watts
- 800 lumens	60 watts	13-15 watts	8-12.5 watts
- 450 lumens	40 watts	9-11 watts	6-9 watts
Other benefits:			
			Compact and adaptable, allowing flexibility in the design
			Low power usage (95% of energy is converted into light and only 5% is wasted)
LED will be chosen due its suitability for this project (F4.3)			

Other essential characteristics of a desk lamp

- Lifetime of desk lamps available in the market is estimated to be 50,000 hours (Melanie Pinola, 2021) (F2.4)
- Weight of desk lamps available in the market is estimated to be 600g (Ben Johnston Matt Reed, 2022) (F5.2)
- Competitors' desk lamps generate 900 lumens with 1300 lux of light to provide sufficient lighting of the desk (BenQ North America, 2019) (F6.1)

Light Design Research (LAMP, n.d.)

Lighting installation must meet both user and space requirements. To this purpose, I will take the following measures to increase user productivity:

Measure title	Measure description
Colour changes (F7.1)	Within the same workspace, cold, neutral or warm lights can be alternated.
	The variation of these shades will help to keep eyes relaxed and working to full capacity
Relationship between colour temperature (CCT) & illumination level (F7.1)	Greater illuminance levels are more comfortable with colder lighting
	Lower illuminance levels are more comfortable with warm lighting
Circadian lighting design (F7.1)	Is the ability to adjust lighting to accommodate daily mental behavioural changes
	Light temperature must change throughout the day, from cooler in the morning to warmer at night
Contrasts strategy (F7.1)	Brightness fluctuation experienced by eyes depends on sensitivity and surface reflectivity
	Good light distribution will eliminate glares
Thus, lighting must be adjustable in terms of brightness and tone, based on factors like the task at hand and the time of day.	
As well as prioritising spaces, accent lighting allows for lighting layers that aid understand the space and create a more inviting atmosphere.	

3. Design Brief (150 words)

The product must follow the correct functionality of a lamp and withstand repeated use as it will be used at least once daily. The final outcome will be a fully-functioning prototype. The product needs to solve two problems:

1. Problem of poor illumination in terms of exposure range and brightness by:
    - Utilising efficient luminants to provide bright illumination
    - Design a lamp structure capable of providing broad light exposure of full entire workspace area
    - Design an adjustable lamp structure to give user control over direction/intensity/colour of luminance
2. Problem of disorganised workspace due to clutter of supplementary products (e.g. wires) by:
    - Integrating utilities inside the lamp to eliminate need of purchasing them separately, hence reducing number of products generating clutter
    - Design a lamp of a compact size

This project is constrained by budgets and is feasible as there is a wide range of manufacturing techniques available and school is very accessible.

4. Design Specifications (793 words)

1. Aesthetic Requirements

1.1 Because consumers will spend a lot of time around the lamp, even when not using it, it must be visually appealing, fit into any residential or workplace context, and be compatible with other items (F1.2).
1.2 The design must be modern, simple, and attractive, as 57% of my target market prefers this style. Appeasing the user's aesthetic preference increases retail value and reduces marketing expenditures (F1.1).

2. Customer Requirements

2.1 This lamp is designed for teenagers and adults who spend long hours at their workstations working or studying in dimly lit environments (F2.1)
2.2 For a good sales revenue, it should immediately appeal to the target market and fill the market gap (F2.1). Reduce workplace clutter (F2.2) and ensure adequate light exposure (F2.3).
2.3 Relative to competitors, the product must last longer (at least 50,000 hours) to create brand loyalty and demonstrate good value for money (F2.4).

3. Cost constraints

3.1 Because this is a “one-off” prototype, the cost will be higher than a final manufactured product. The lamp's retail price is $200, based on user research, thus it must be cheaper than $200 to compete and attract customers (F3.1).
3.2 Lower manufacturing costs cover expenditures and create profit (F3.1).
3.3 Product should be affordable and present itself as good value for a student and adult (F2.1, F3.1).

4. Environmental Requirements

4.1 Less material must be utilised to make the product more eco-friendly and appealing to a wider variety of consumers. This reduces the eventual disposal and replacement costs (F4.1, F4.2)
4.2 The product must be disassembled readily. This will reduce space and thus energy in transportation, as well as allow for easy repair or upgrade, extending product life and allowing for component reuse (F4.2, F2.2, F2.4).
4.3 Use the same/repetitive components whenever possible to conserve money and materials.
4.4 To save money and help the environment, low-power LEDs (12V OC) should be utilised and powered by 240v mains via a transformer (F4.3, F4.2)

5. Size constraints and Ergonomic considerations

5.1 Size of the lamp must be suitable for constrained workspaces, covering the smallest amount of space while efficiently utilising space provided (F2.2, F5.1).
5.2 The product's shape and size must be adaptable to accommodate a larger range of workspaces and user preferences (F5.1).
5.3 Weight must be lighter than 1kg to aid portability and reduce distribution costs (F5.2)
5.4 Must be less than 90cm wide and 80cm tall to increase stability (F5.1 - Figures 3 and 6). Buttons and controls must be 18mm wide and high (F5.1 - Figure 4). Design must not obstruct 75 degree visibility or operability with desk objects (F5.1 - Figure 5).

6. Safety considerations

6.1 Given that the product will be used in a household setting, it is essential that the circuit be free of faults and that the bulbs be hidden (F1.2)
6.2 Because the product is meant for use in homes, it must have smooth surfaces and edges to avoid cuts (F1.2)
6.3 To ensure user safety and allow usage in domestic environments (F1.2), the lamp must meet BSI & CE requirements.
6.4 Must stay on the desk and endure human medium compressive pressures (F5.1)

7. Function

7.1 Must provide wide exposure of efficient illumination with at least 1300 lux of both efficient task and appealing ambient lighting to allow performance of visual tasks of medium contrast or small size (eg: reading) in both light and dark settings (F6.1)
7.2 By incorporating USB port charging hub, and any other utilities within the lamp, it should help reduce workspace clutter and enhance organisation (F2.2, F7.2)
7.3 Should incorporate a manual circadian lighting design by using flexible LEDs luminaries to keep the circadian cycle stable within a building, by giving users the ability to regulate luminance temperature, intensity and colour (F2.1, F7.1, F4.3)
7.4 Light direction should be adjustable as it is necessary due to the location and the personal preference of the user to illuminate multiple parts of the workspace (F2.3, F5.1)
7.5 Any buttons/ports/remote controls are provided, they must be simple & intuitive to operate with as the product will be used in households (F1.2)

8. Manufacturing Requirements

8.1 The product must be manufactured within the restrictions of the technology and materials available in the school workshop indicated in F9, and within the time constraints of 20 hours by considering the speed of manufacture of different materials/technology used (F8.1).
8.2 Must utilise standard components for additional components to reduce costs of manufacturing and price of product (F3.1).
8.3 It must produce minimal waste during manufacturing to to minimise losses and become a more eco-friendly product (F4.2).

9. Material Requirements

9.1 Must be made out of materials that can be finished to give a smooth surface and to protect the product, prevent injuries, increase safety and allow for easy cleaning (F4.1)
9.2 Be made out of materials which are good electrical insulators to protect the user from electrical injuries (F4.1).
9.3 Aesthetics of materials must visually match and be in harmony with other parts of the lamp to make it aesthetically pleasing to the target user (F2.1, F1.1, F4.1)
9.4 Must be made out of materials for which integration of electronics is feasible for this project; it must be done quickly and with readily available technologies (F4.1)

Criterion B

1. Initial ideas sketches

Idea 1

Petals are of same shape, reducing costs and saving materials (Spec 4.3)

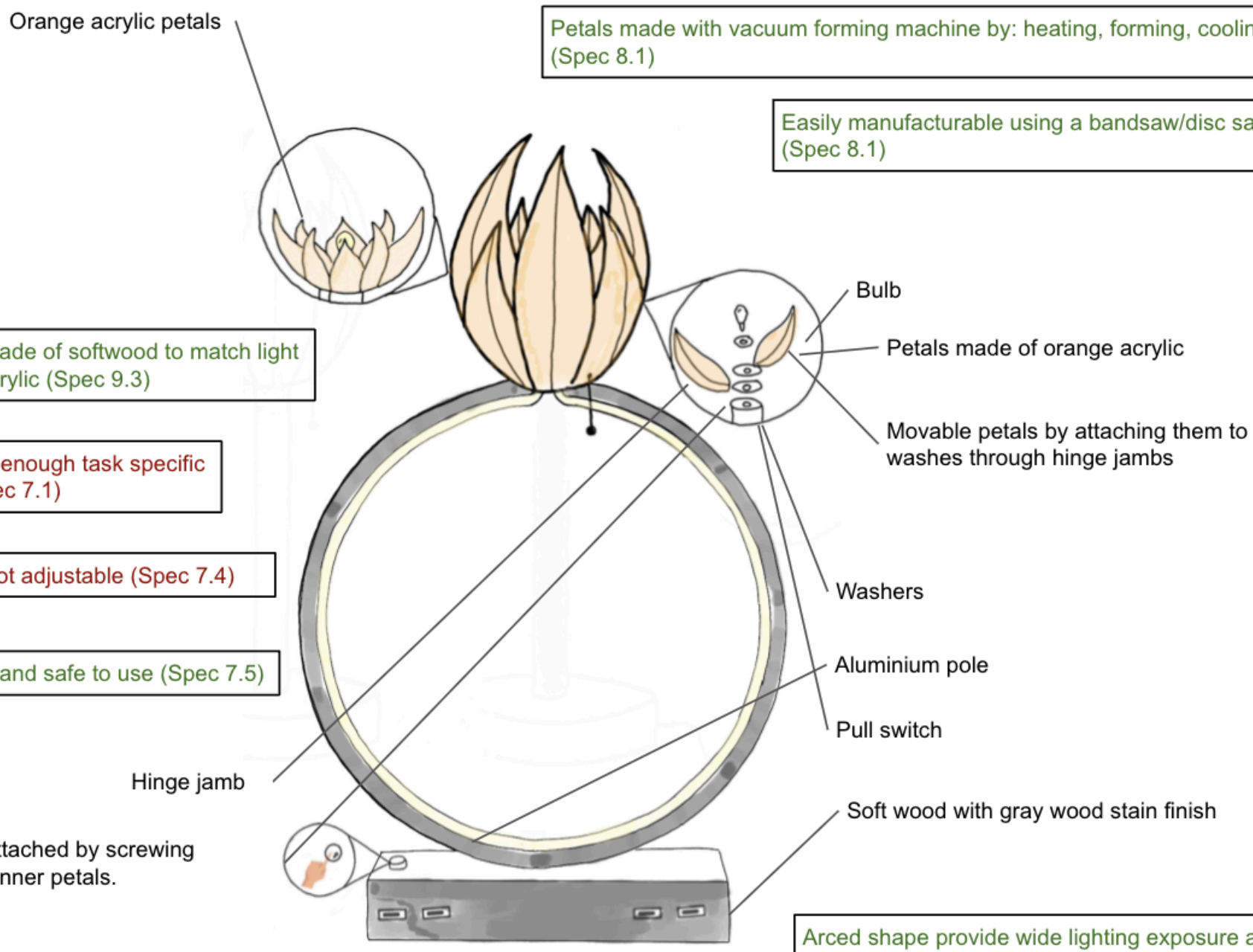
Bulb lacks protection, making it dangerous when petals are opened (Spec 6.1)

Orange acrylic petals give an appealing ambient light (Spec 7.1, 9.3) to surrounding

Orange acrylic petals are easy to shape (Spec 9.5)

Petals made with vacuum forming machine by: heating, forming, cooling (Spec 8.1)

Easily manufacturable using a bandsaw/disc sander (Spec 8.1)



Wooden base is made of softwood to match light tones of orange acrylic (Spec 9.3)

Unlikely to provide enough task specific light exposure (Spec 7.1)

Light direction is not adjustable (Spec 7.4)

Pull switch is easy and safe to use (Spec 7.5)

The pull switch is attached by screwing through one of the inner petals.

Arced shape provide wide lighting exposure and ambient lighting (Spec 7.1)

Light color isn't adjustable (Spec 7.4, 7.3)

Acrylic used for petals is easily reusable (Spec 4.1)

Finishing aluminum poles is quick and easy (Spec 8.1, 9.1)

Aluminium circular pole is lightweight - aiding portability (Spec 5.3)

Finishing softwood is quick and easy (Spec 8.1, 9.1)

Aluminium pole is difficult to manufacture (Spec 8.1)

Finishing aluminium pole makes it look appealing (Spec 1.1)

Easy electronic integration by pre-designing holes in CAD for USB ports (Spec 9.4)

Both the base and the pole are made of sustainable material - softwood (Spec 4.1)

Dimming system allows user to adjust light intensity (Spec 7.3)

Idea 2

Moderate light exposure of both task specific and ambient lighting (Spec 7.1)

Soft wood for base is a sustainable material (Spec 4.1)

Light bulb is exposed to user, making prone to breakage (Spec 6.1)

Aluminium can easily be shaped by pressing it on a wooden mould (Spec 8.1)

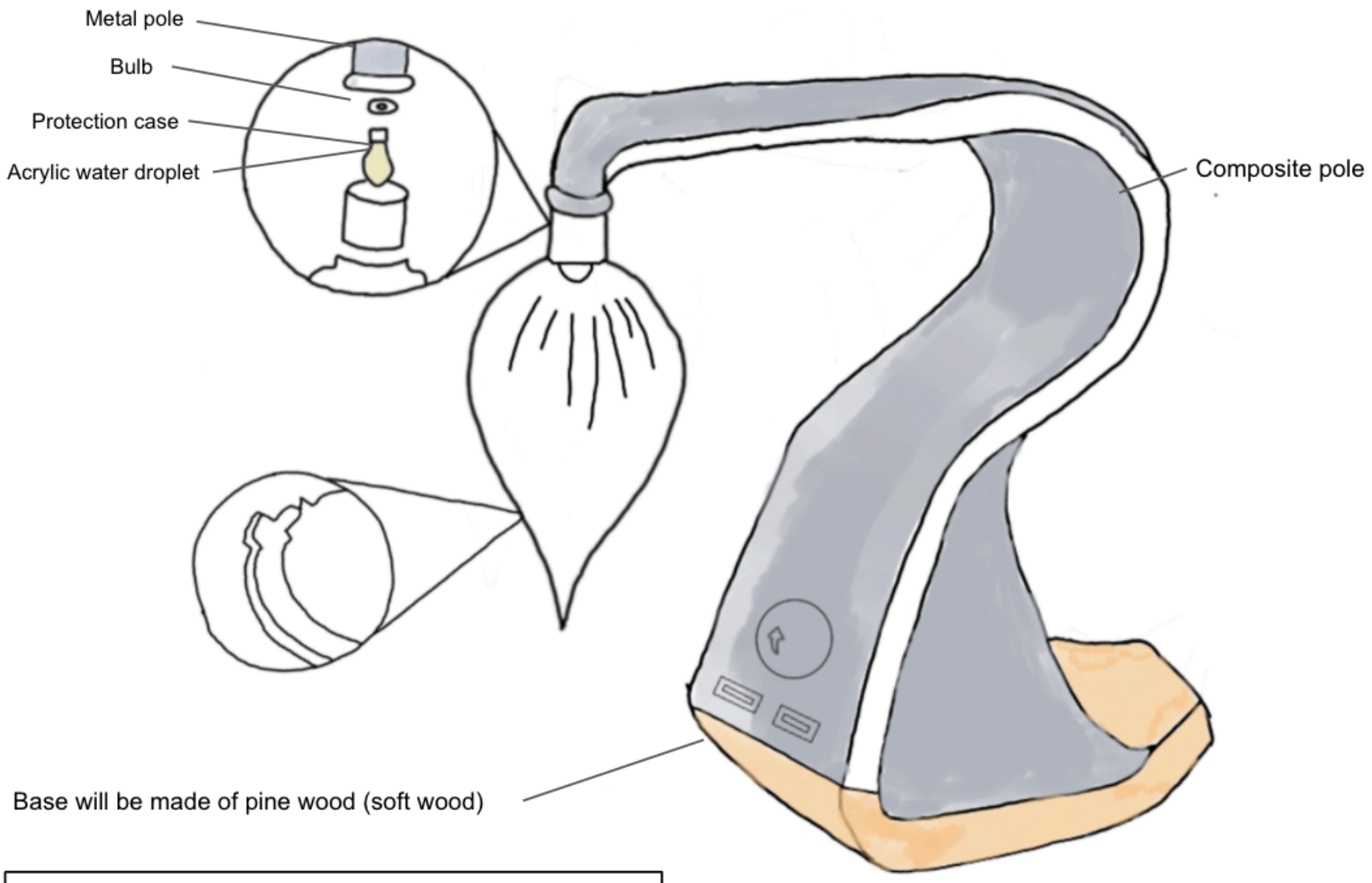
Using hacksaw & pillar drill, aluminium pole can be shaped & built into base (Spec 8.1)

Time consuming to process of components with epoxy resin (Spec 9.4)

Neither light direction nor light color can be adjusted which reduces (Spec 7.3, 7.4)

Hard to integrate electronics as it requires sawing holes in softwood base (Spec 9.4)

USB charging integration reduces clutter of user's workspace (Spac 7.2)



Pole is a composite, with layers: Aluminium, Foam and Aluminium (Spec 9)

Silent touch light regulation to adjust the light intensity (Spec 7.3)

Aluminium can easily be shaped by pressing it on a mould (Spec 8)

Pine wood base is lightweight aiding ease of transportation (Spec 5.3)

Aluminium for the pole is a sustainable material (Spec 4.1)

Aluminium layers will provide a finish making it more pleasing (Spec 9.3)

Materials are easily manipulative and aesthetically pleasing (Spec 9)

Pine wood base has aesthetically pleasing grains (Spec 9.3)

Acrylic used for droplet is easily reusable (Spec 4.1)

Composite material will make product more pleasing (Spec 9.3), durable (Spec 2.3), easily manufacturable (Spec 8.1)

Time consuming to hide imperfections of epoxy resin (Spec 9.4)

Hard electronics integration as it requires sawing aluminium pole holes (Spec 9.4)

Idea 3

Light color/temperature isn't adjustable (Spec 7.3)

Lamp is not adjustable and the direction of the light cannot be altered (7.4)

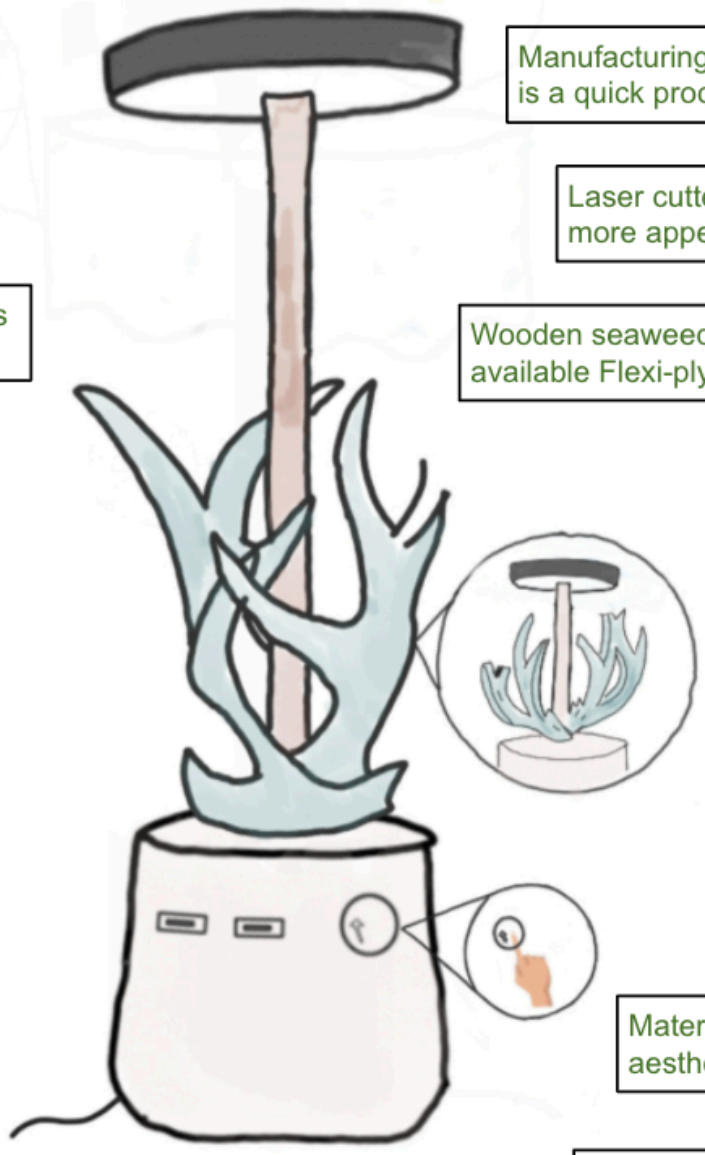
Limited provision of task specific light exposure (Spec 7.1)

Hardwood pole to hold the shade - increases stability (Spec 6.4)

Hardwood pole protects from accessing wires that run through it (Spec 6.1)

Marine colors positively contribute towards increased productivity of user (Spec 2.1)

Patterns to seawood can be added with laser cutter (Spec 1, 8.1)



Manufacturing seaweed with flexiply using laser cutter is a quick process (Spec 8.1)

Laser cutter allows adding patterns to make design more appealing (Spec 2.1)

Frosted polypropylene has a light carbon footprint and is biodegradable (Spec 4.1)

Wooden seaweed is manufactured using cheap and readily available Flexi-ply (Spec 3.2)

Wooden seaweed can be sanded to smoothen and ensure safety (Spec 6.2, 8.1)

USB charging integration reduces clutter of user's workspace (Spac 7.2)

Materials are easily manipulative and aesthetically pleasing (Spec 9)

Hidden wires effectively avoids electrical accidents (Spec 6.1)

Silent touch light regulation to adjust the light intensity (Spec 7.3)

Soft wood used for base and pole, is a sustainable material (Spec 4.1)

Hard to integrate the cable as it will run through wooden base to USBs and the bulb (Spec 8.1)

Assembling with silicone glue is time consuming and error prone (Spec 9.4)

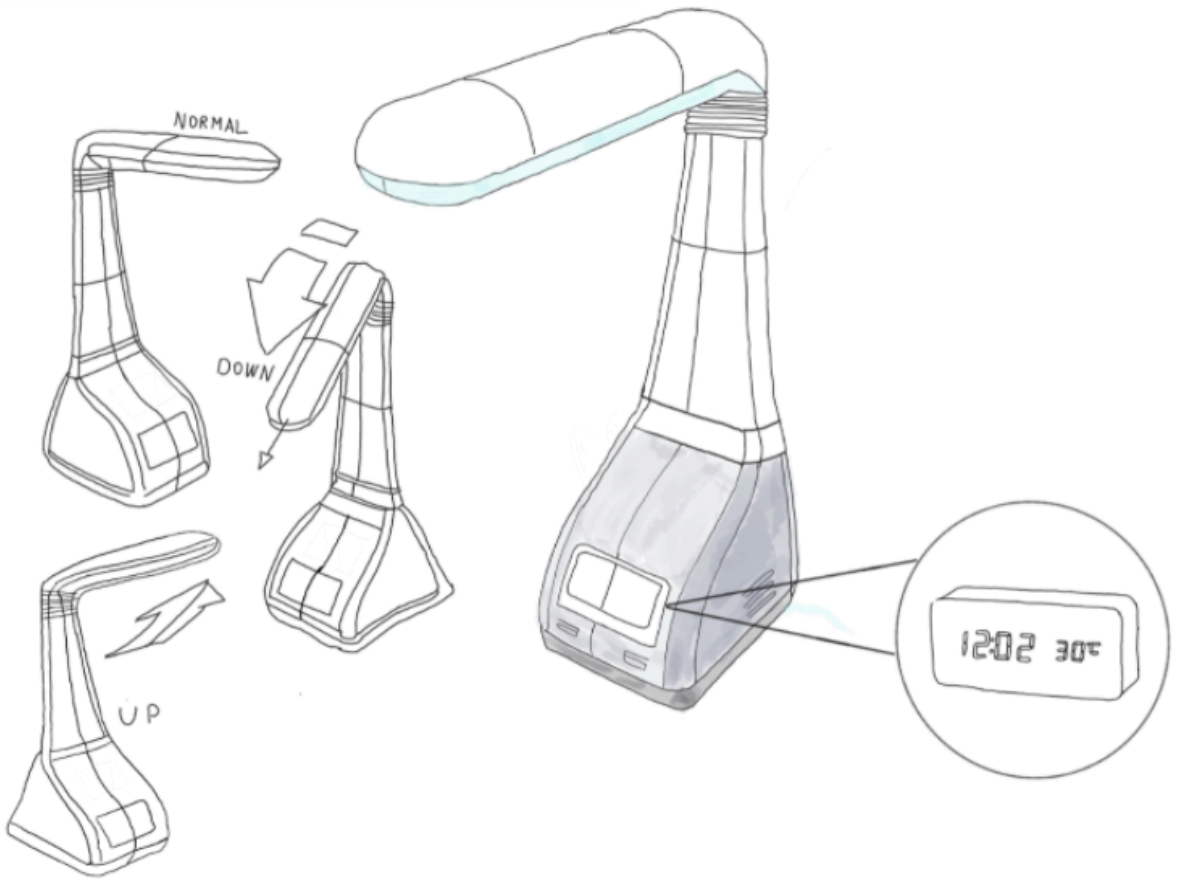
Seawood is made by cutting and gluing layers of flexiply (Spec 8)

Time consuming electronics integration due to need of resawing base (Spec 9.4)

Hiding imperfections by finishing is time consuming and error prone (Spec 9.4)

Idea 4

Hard to manufacture in school due to complex components' combination (Spec 8)



Only smooth rounded edges make it very safe (Spec 6.2)

Moderate light exposure of task specific lighting (Spec 7.1)

Efficient LEDs as the light source (Spec 4.4)

Not enough ambient lighting exposure (Spec 7.1)

LED strips are hidden from users preventing electrical injuries (Spec 6.1)

Integration of clock aids reduces clutter of user's workspace (Spec 7.2)

Integration of two USB ports reduces clutter of user's workspace (Spac 7.2)

Easily adjustable light direction by turning the lamp head (Spec 7.4)

A lot of material is required for manufacturing, space isn't being used efficiently (Spec 5.1)

Electronics integration by pre-designing holes in CAD to clock size (Spec 9.4)

Attaching electronics with epoxy resin is easy and fast (Spec 9.4)

Electronics integration by pre-designing holes in CAD to USB-ports' size (Spec 9.4)

Idea 5

Materials are easily manipulative and aesthetically pleasing (Spec 9)

Plywood composite is cheap (Spec 3.1), lightweight (Spec 5.3), has pleasing wood/glue layers (Spec 1.1)

It is designed for disassembly and hence can be easily disassembled (Spec 4.2)

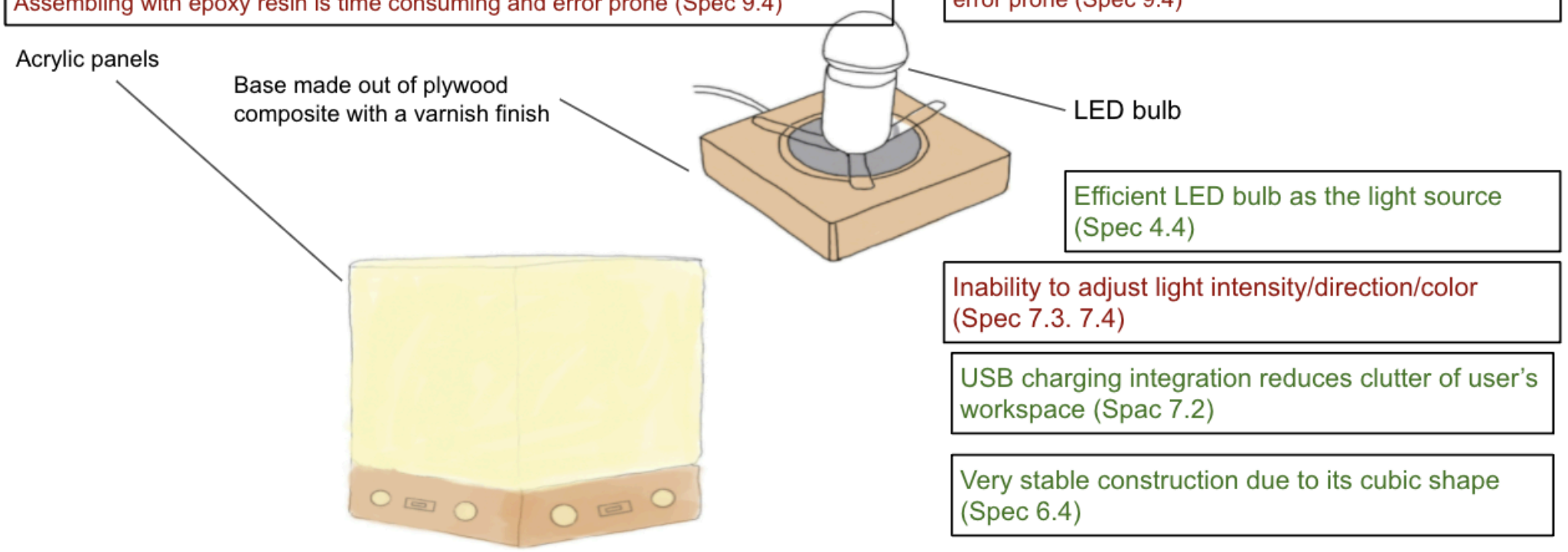
Protective case and no exposed electronics increases user safety (Spec 6.1)

It has abundant sharp edges may pose risk of injuries for user (Spec 6.2)

Hiding imperfections by finishing is time consuming and error prone (Spec 9.4)

Sawing holes in softwood for electronics integration is error prone (Spec 9.4)

Assembling with epoxy resin is time consuming and error prone (Spec 9.4)



Efficient LED bulb as the light source (Spec 4.4)

Inability to adjust light intensity/direction/color (Spec 7.3. 7.4)

USB charging integration reduces clutter of user's workspace (Spac 7.2)

Very stable construction due to its cubic shape (Spec 6.4)

Lamp's flat surface allows adding vinyl stickers for greater customization (Spec 7.4)

Multi-directional light emission ensures all workspace areas are illuminated (Spec 7.4)

Minimalistic design make it suitable for wide range of workspaces (Spec 1)

Idea 6

Exposed electronics pose risk of injuries for user (Spec 6.1)

Light color is adjustable, so greater customisation allowed to user (Spec 7.3)

Remote-control allows users to change light color from long distance (Spec 7.5)

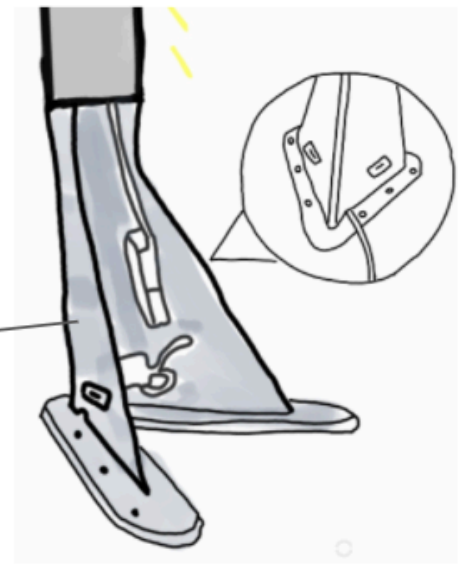
Provide wide lighting exposure of both ambient and task lighting (Spec 7.1)

Foot bases supporting the lamp increases its stability and safety (Spec 6.4)

Suitable for wide range of environments due to minimalistic design (Spec 1.1)

Multi-directional output ensures wide illumination covering all workspace areas (Spec 7.4)

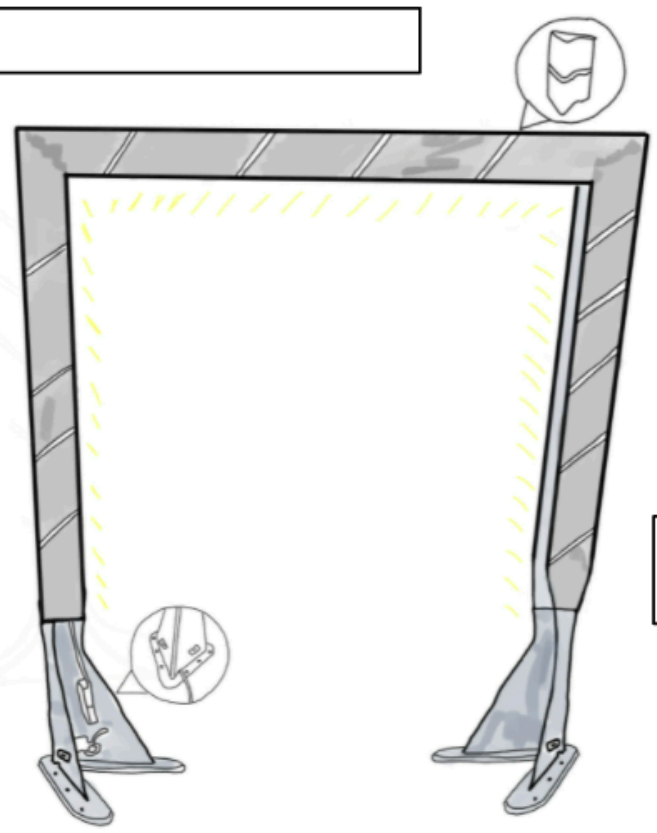
Abundant amount of sharp edges pose risk of injuries for user (Spec 6.2)



Light direction is not adjustable (Spec 7.4)

Hidden wires and circuits (Spec 6.1) makes the lamp safe to use

Each foot base is the same shape, reducing manufacturing costs (Spec 4.3)



Exposed electronics reduce product lifetime (Spec 2.3)

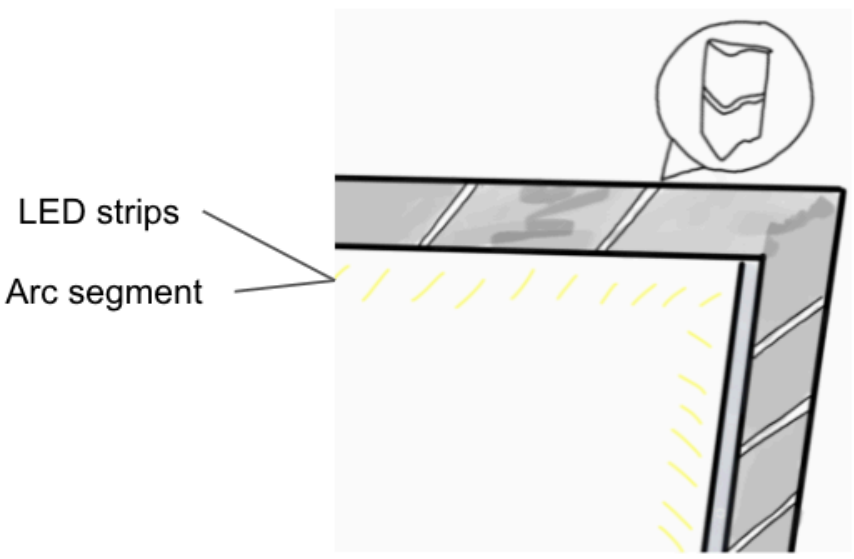
Efficient LEDs as the light source (Spec 4.4)

Assembling plastic components & electronics is easy/fast (Spec 9.4)

Integration of four USB ports reduces clutter of user's workspace (Spac 7.2)

Electronics integration by pre-designing holes in CAD to USB-ports' size (Spec 9.4)

Easily adjustable to any desk size by printing additional arc segments and joining them using the joints (Spec 5.2)



Arc-segment relies on adhesives making it hard to disassemble components (Spec 4.2)

(Spec 7.3) Light intensity is not adjustable

(Spec 5.2) Adjustable shape by customizing numbers and direction of arc segments

Components manufactured with 3D printing ensure little waste and accuracy (Spec 8)

Major components can be manufactured using sustainable 3D printing materials (Spec 9)

Innovative construction minimizes space consumption, aiding workspace clutter reduction (Spec 2.2, 5.1)

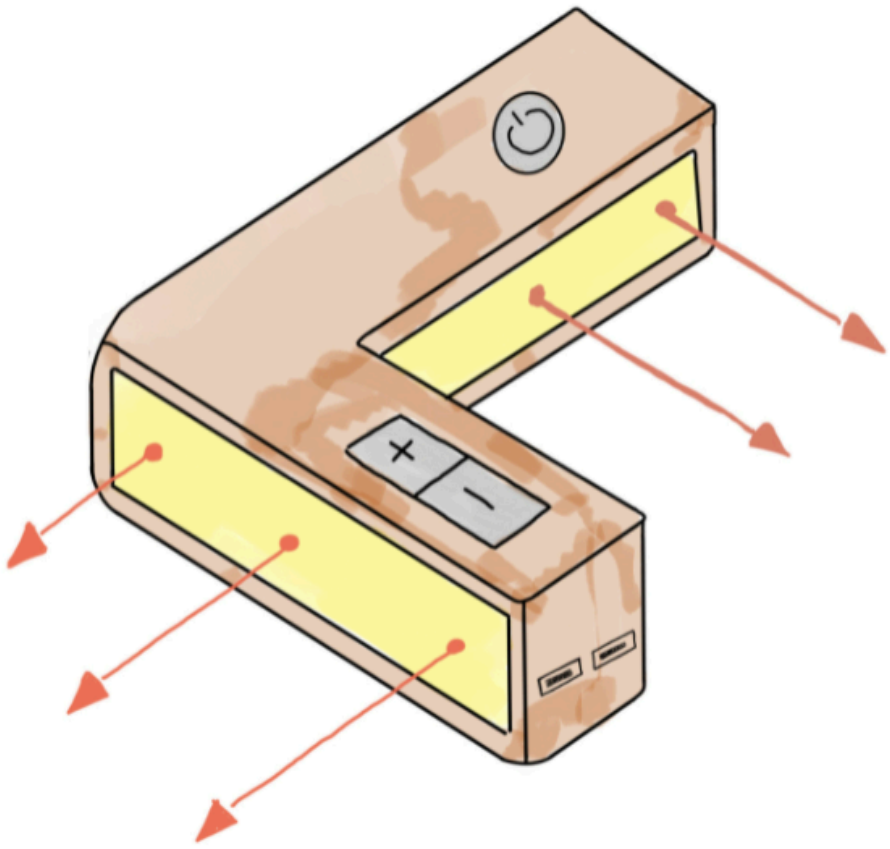
Initial Product Evaluation against Design Specification						
Design Spec.	**Idea 1**	**Idea 2**	**Idea 3**	**Idea 4**	**Idea 5**	**Idea 6**
Aesthetic	10	7	9	10	10	10
Customer	7	7	8	9	9	9
Cost	7	9	9	10	10	10
Environmental	10	10	9	9	10	10
Safety	7	8	8	9	8	9
Size	9	7	8	9	10	10
Function	10	9	9	10	9	10
Manufacturing	10	8	10	10	10	10
Materials	9	8	10	8	8	10
User feedback	Has an unstable structure and limited adjustability of colour/direction	Lamp has the potential to provide very efficient task lighting	Unique marine design has the potential of increasing lamp's adoption	Combines numerous technologies, making it more appropriate for constrained workspaces	I like the minimalistic design and multi-directional light output	Design is innovative and it has broad light exposure
	Has pleasing ambient lighting, but insufficient provision of task lighting	Seems unsafe as the bulb is exposed, making it prone to breakage	Lamp is unable to provide enough task lighting	Product wastes a lot of space and materials	Because it allows lamp placement in various areas	Lamp shape seems unsafe and may cause accidental injuries
	Providing enough lighting is the most important criteria for a lamp		Limited adjustability of light makes it unsuitable for my workspace	Large portions of product are covered with plastic with no usefulness	Lamp light should be customizable in terms of colour/intensity/direction	I suggest the shape to be more round or maybe adjustable.
	Design seems very innovative and I love the circular shape			This makes the product less ecologically friendly		It might be better if the lamp would have the ability to change light colours
	5	**7**	**8**	**9**	**9**	**10**
Total	84	80	88	93	93	98
Conclusion	After analysing my design concepts in relation to the design specification and after talking to my client about 3 potential best designs, I have chosen to continue pursuing the following design ideas: 4, 5, and 6.					

2. Initial concept modelling

The concepts presented in Criterion B1 are very different from one another, and each has its own individual merits. In order to decide which concept is most suitable for my client, I will build some full and partial prototypes for each of the concepts.

Concept 1 model

Concept 1 (from Idea 5)



Multi-directional light emission allows for wide range of lighting exposure (Spec 7.4)

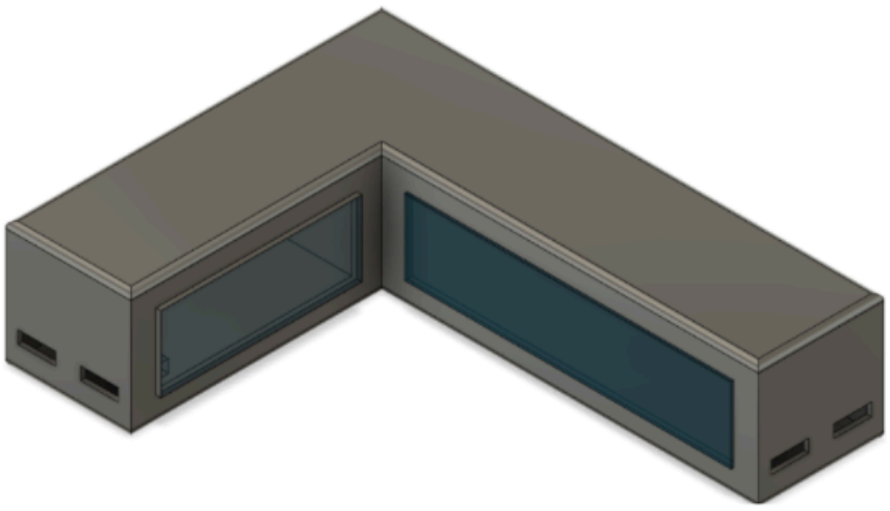
Minimalistic design might appeal to wider range of market segments (Spec 1.1, 1.2)

Pleasing aesthetics will contribute towards its widespread adoption & omnipresence (Spec 1.1, 1.2)

Gluing acrylic panels onto wood is complex and time consuming (Spec 8)

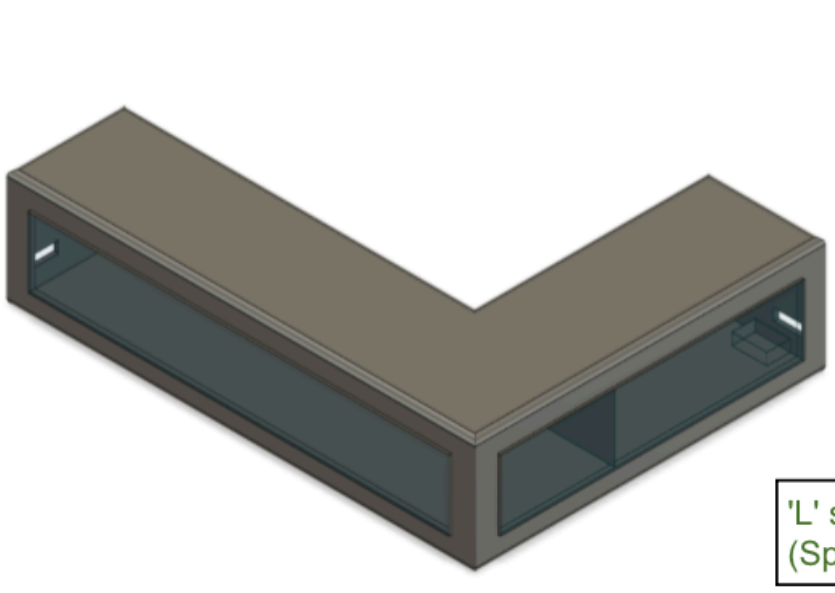
Attaching PCB to the base is complex and time consuming (Spec 8)

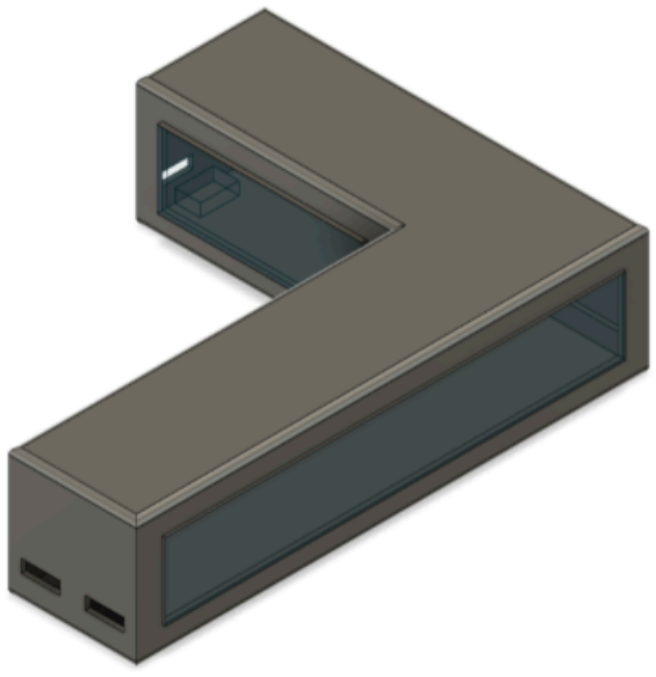
3D Graphical Modelling (digital drawings)



Four USB-ports from different sides contribute to reducing workspace clutter (Spec 8.1, 8.3)

Efficient positioning of USB-ports make them more intuitive to utilise (Spec 8.1, 8.3)





'L' shape offers wide variety of positioning options in user's workplace (Spec 5.1, 5.2)

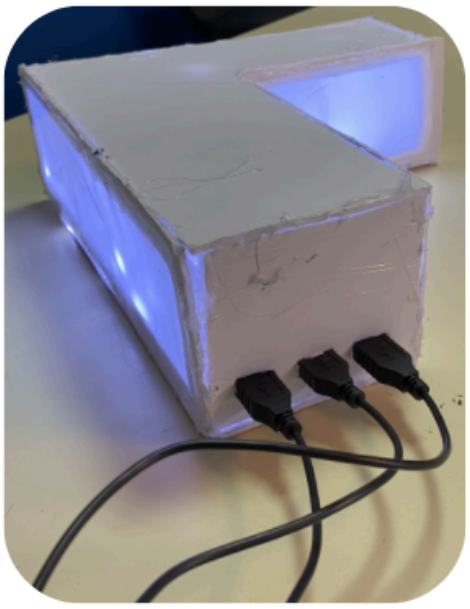
Rounded corners reduce risk of accidental injuries (cuts) (Spec 5.1, 5.2)

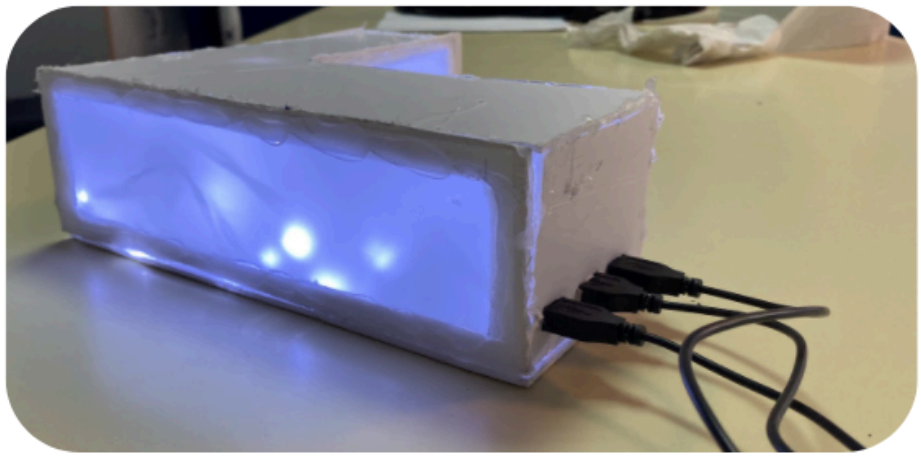
Reduced manufacturing costs will increase affordability and adoption of innovation (Spec 8.1, 8.3)

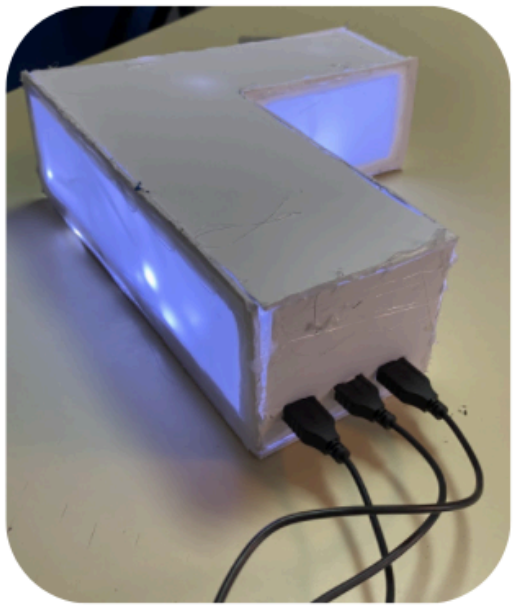
It's manufacturable with only 8 parts, hence reducing manufacturing speed/waste (Spec 8.1, 8.3)

Concept 1 (from Idea 5)

Physical Modelling & Evaluation based on observation of users using the concept (in scale of 1:1)







User feedback in terms of Design Specifications

Strengths:

(Spec 5.1) Maximises space usage by covering most area with light-emitting windows

(Spec 6.1) Internal bulbs are hidden behind walls reducing risk of injury

(Spec 5.3) Efficient use of materials make it lightweight, aiding transportation ease

(Spec 6.4) Large flat surface area ensures stability on desk

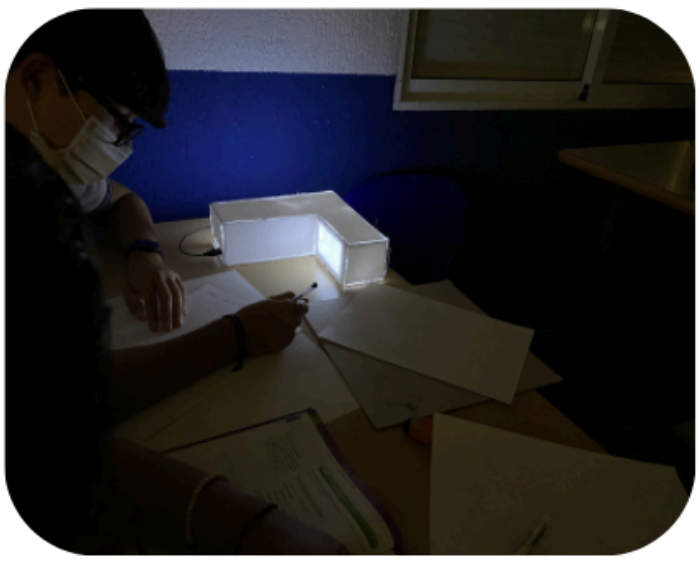
(Spec 2.2) Advantages of innovation are immediately observed over existing lamps

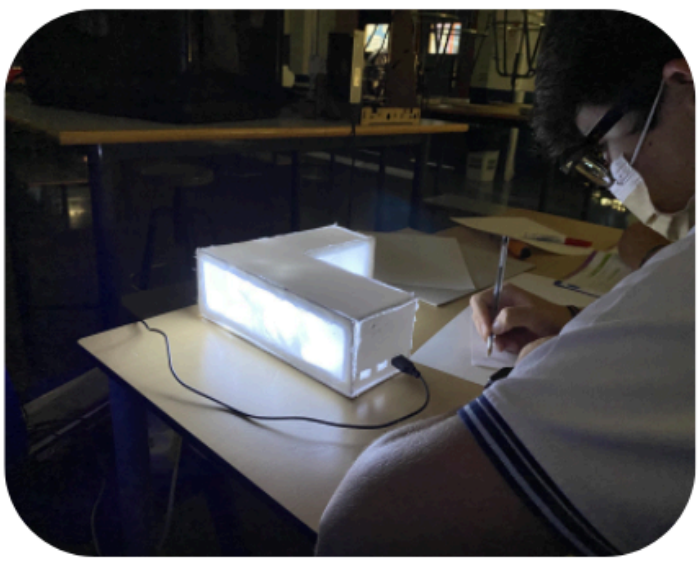
(Spec 7.2) USB-ports integration optimizes use of space and reduce workspace clutter

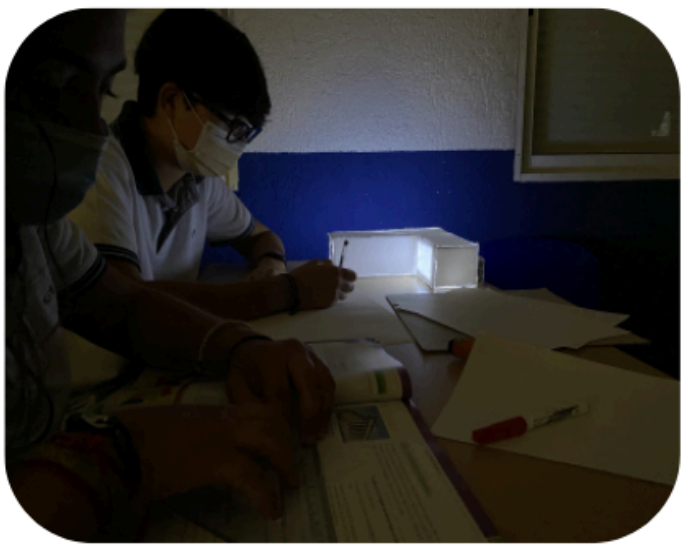
Weaknesses:

(Spec 7.1) Insufficient light output to cover entire workspace, reducing user's productivity

(Spec 5.2 & 7.4) Inability to adjust shape and light direction



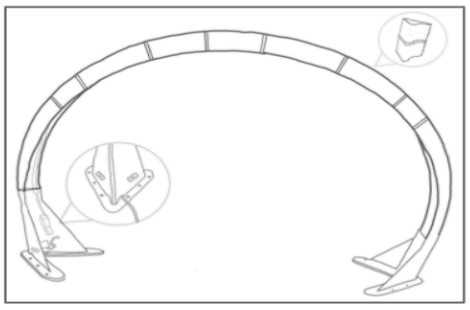




Concept 2 model

Concept 2 (from Idea 6)

Changing the form of the structure by bending the arc-segment



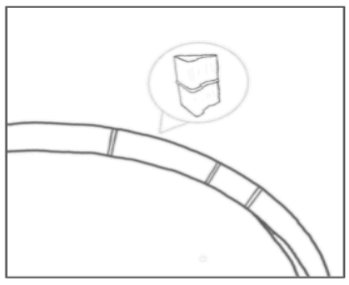
Integration of LED controller to adjust light color/intensity

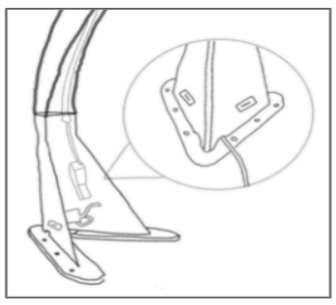
LEDs will be purchased with ability of controlling light intensity and color via a remote control

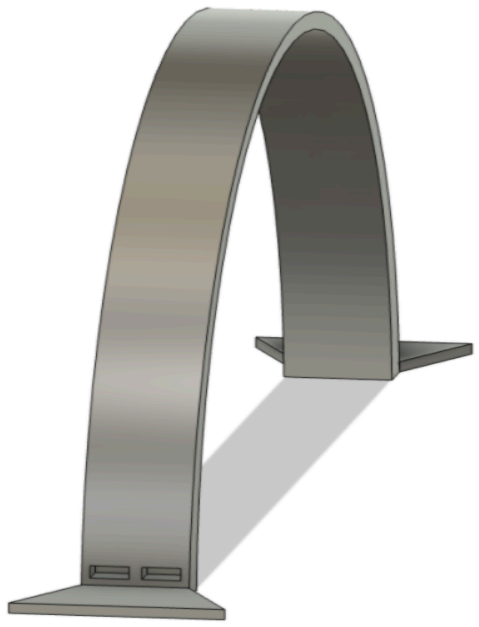
(Spec 5.2) Bent shape of arc-segments allows for construction of arc-like construction

(Spec 5.2) Shape and size is adjustable, allowing it to fit a wide range of workspaces

(Spec 4.2) Heavily relies on adhesives making it hard to disassemble and not adjustable at all







Concept 2 (from Idea 6)

Physical Modelling & Evaluation based on observation of users using the concept (in small scale 2:1)

User feedback in terms of Design Specifications

Strengths:

(Spec 7.1) Light exposure is wide and bright covering entire user's workspace

(Spec 1.2) Minimalistic design will suit a wide range of workspaces

(Spec 7.5) USB ports are easily identifiable, accessible and safe

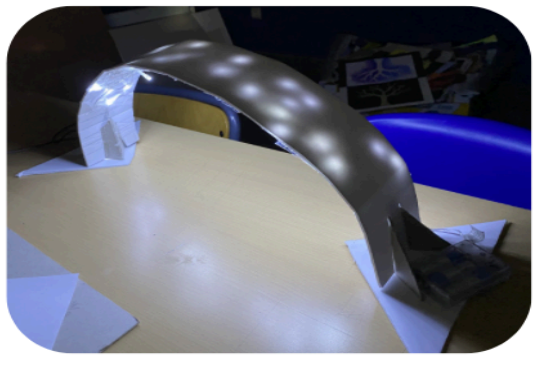
(Spec 7.2) Four USB-ports are provided greatly contributing to reducing workspace clutter

Weaknesses:

(Spec 6.1) - Cables are exposed to user, increasing risk of injuries

(Spec 1.1) - Cables are exposed to user, making it less aesthetically pleasing

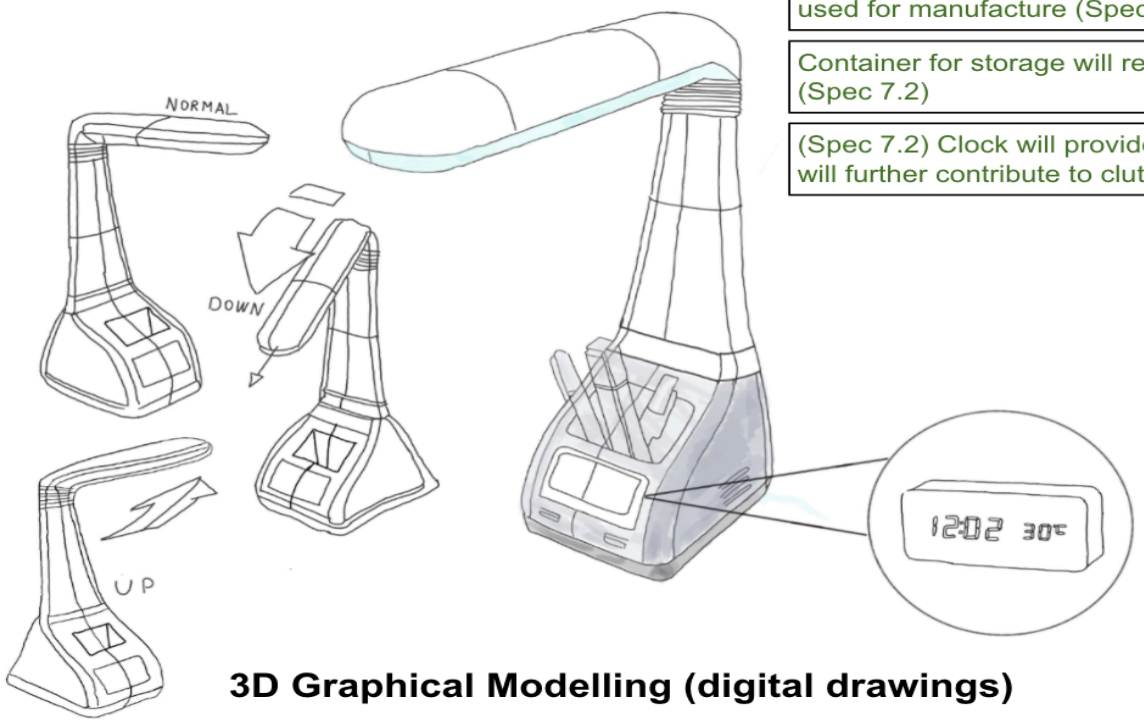
(Spec 6.4) - Exposed cables reduce durability and potentially product's retail value



[Concept 3 model]

Concept 3 (from Idea 4)

3D Graphical Modelling (drawings)



Container for storage will reduce amount of materials used for manufacture (Spec 4.1)

Container for storage will reduce workspace clutter (Spec 7.2)

(Spec 7.2) Clock will provide an additional utility which will further contribute to clutter reduction

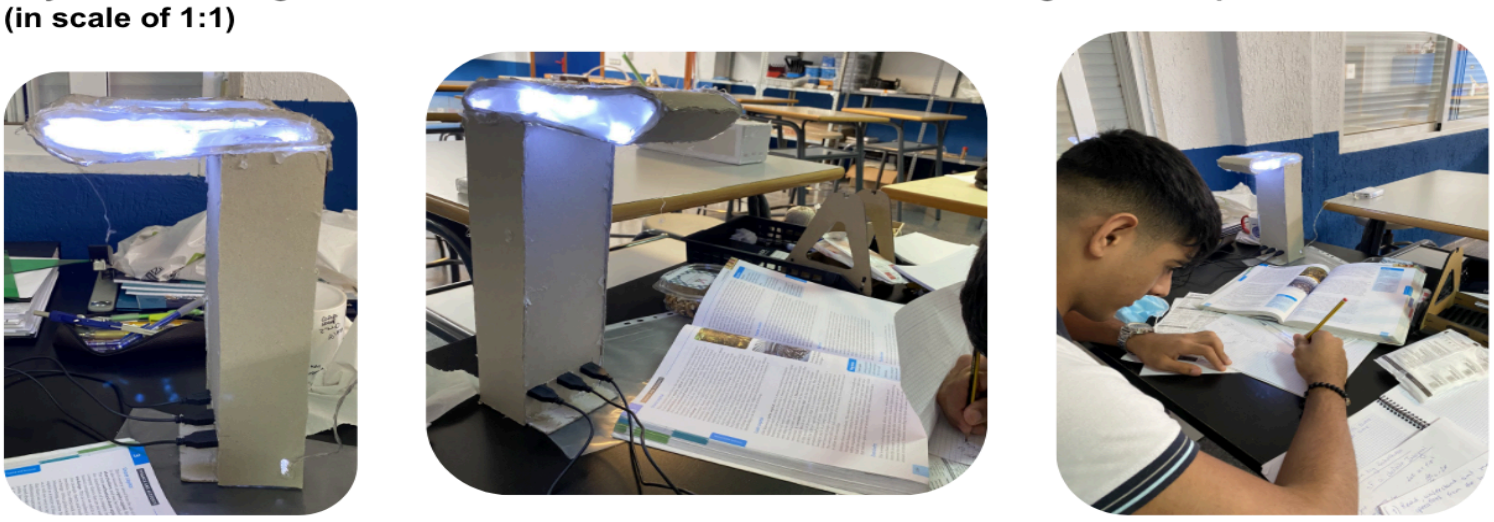
3D Graphical Modelling (digital drawings)

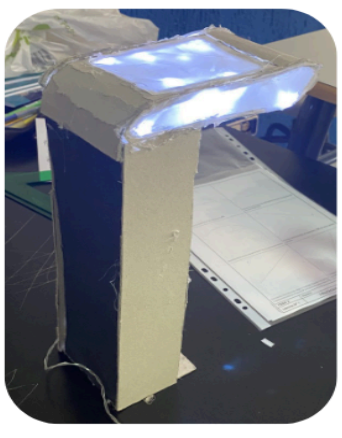
(Spec 5.1, 5.4) Has small surface area, so occupies little desk space - making it suitable for constrained workspaces

(Spec 7.2) Only integrates two USB ports which might be insufficient for all users

Concept 3 (from Idea 4)

Physical Modelling & Evaluation based on observation of users using the concept (in scale of 1:1)





User feedback in terms of Design Specifications

Strengths:

(Spec 6.1) Pole safely hides internal bulbs/circuits - reducing risk of injury

(Spec 7.1) Provides sufficient light exposure covering full area of the workspace

(Spec 1.2) Minimalistic design will suit a wide range of users' workspaces

(Spec 1.1) Lamp is similar to regular lamps increasing product's compatibility

Weaknesses:

(Spec 6.4, 2.3) Small surface area & tall height make it unstable/unsafe.

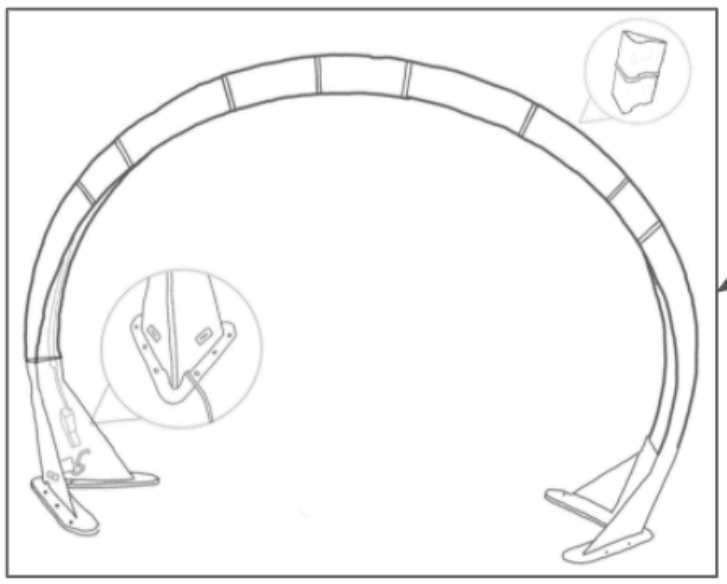
(Spec 7.4) Unadjustable light direction - unsuitable for wide range of users' workspaces

3. Evaluation against design specification

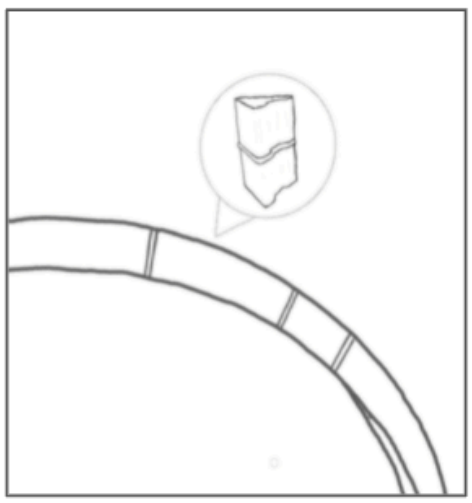
Final Product Evaluation of three concepts against Design Specification and Feasibility of ideas			
Design Specification = Blue Feasibility = Red			
	Concept 1	**Concept 2**	**Concept 3**
Aesthetic	10	10	10
Customer	10	9.5	10
Originality	9	10	9
Cost	10	10	10
Environmental	10	10	10
Environmental friendliness	9	9	9
Safety	10	9.5	9
Size	10	10	9
Function	10	10	10
Manufacturing	8	10	10
Possibility of manufacture	7	9	8.5
Materials	9	10	9
Availability of materials	8	9	9
User feedback	9	10	9
Total for Design Specification	96	99	96
Total for Feasibility	33	37	35,5

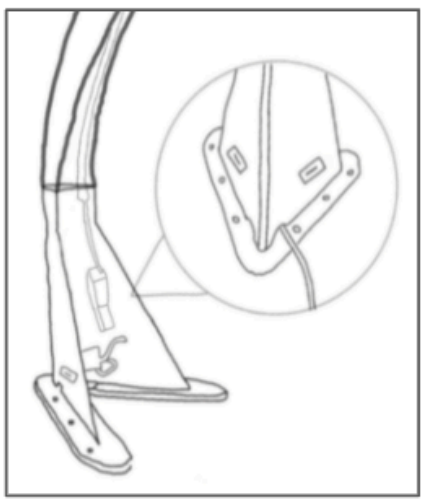
4. Justification

Justification of chosen design concept (2nd)



- Provides wide exposure of both task and ambient lighting (Spec 7.1)
- Incorporates numerous (4) USB charging sockets (Spec 7.2)
- Only uses efficient LED lighting (Spec 4.4)
- Construction is highly efficient in terms of space usage (Spec 5.1)





USER FEEDBACK that contributed to choice of the design

- (Spec 1) “I like futuristic aesthetics which make the lamp stand out”
- (Spec 5.1, 7.1) “I like efficiency of space usage and design’s bright illumination”
- (Spec 7.2) “I like integration of USB-ports, which will reduce my workspace clutter”

In conclusion, after re-analysing the chosen final three design concepts in relation to the design specification and after talking to my client about them to try and determine the best idea to carry forward. I have chosen the 2nd design as my final design for detailed development.

Firstly, it received the highest points for the design specifications and feasibility study, implying that it is the most feasible and applicable. Following user testing, the customers stated that the first and second ideas are the best for them for reasons such as effective adjustability, wide light exposure, visually pleasing designs, and efficient use of space, all of which fit under the design specification's major objectives. However, the second idea was chosen above the first because it offered more customizability, flexibility, and an innovative arc-like shape that allowed for effective space use in constrained workplaces.

Possible materials for 3D printing = PLA / ABS / TPU95A (Z1)

Evaluation against design specification	
Design specification criteria	**Explanation**
1. Aesthetic Requirements	1.1 Minimalistic design allows it to fit a wide range of environments
	1.1 Minimalistic design makes it pleasing to wide range of market segments
	1.2 As stylish and fashionable product, it successfully appeals to target market
2. Customer Requirements	2.1 Suitable for a wide range of users due to elegant aesthetics and usability
	2.2 Provides highly efficient and broad illumination through installation of LED-strips
	2.2 Flexibility of customisation allows compactness and efficient usage of space
	2.2 Can provide numerous USB-ports to reduce workspaces' clutter
	2.3 Use of tough materials (Z1) and disassemblable/repairable components - increases product's durability
3. Cost constraints	3.1, 3.2, 3.3 Low manufacturing costs due to use of cost-effective materials and standard components
4. Environmental Requirements	4.1 Possible materials (Z1) are completely recyclable
	4.2 Both arc-segments and foot-bases are disassemblable and sub-parts replaceable
	4.3 Components can be re-printed in any quantity for shape adjustability - saving materials
	4.4 LEDs are will consume relatively small amount of energy
5. Size constraints and Ergonomic considerations	5.1 Arc-like structure takes little space, so suitable for constrained workspaces
	5.2 Adjustable shape and dimensions by printing additional arc-segments or foot-bases
	5.3 Weight is adjustable to user's preferences based on desired shape
	5.4 Width is adjustable to user's preferences based on desired shape
6. Safety considerations	6.1 Base design will be improved to hide electronics and cables
	6.2 Surfaces of components will be smoothed out to prevent injuries
	6.3 Compliance can be obtained as currently the lamp passes the criteria
	6.4 Leg-like structure of bases and screws ensures stability
7. Function	7.1 LED-strips provide about 800 lux
	7.2 Incorporates 4 USB charging ports
	7.3 LED-strips with remote control allows for light intensity and colour alterations
	7.4 Rotational mechanism will be added to base to allow light direction adjustability
	7.5 Absence of buttons increase intuitiveness and ease of operation
8. Manufacturing Requirements	8.1 It can be made using components of school's workshop, reducing costs and complexity of manufacture
	8.2 Usage of standard will reduce manufacturing costs and product's price
	8.3 Additive manufacturing process of 3D Printing will produce little waste
9. Material Requirements	9.1 Materials (Z1) can easily be finished to create a smooth surface
	9.2 Materials (Z1) has excellent electrical insulation properties
	9.3 Materials (Z1) are classically coloured, so suitable for a wide range of environments
	9.4 Ability to pre-design components to suit electronics installation will reduce manufacturing time/costs

Arc Segment Modifications and Selection

Arc Segment 1

(Spec 4.2) Heavily relies on adhesives making it hard to disassemble and unadjustable

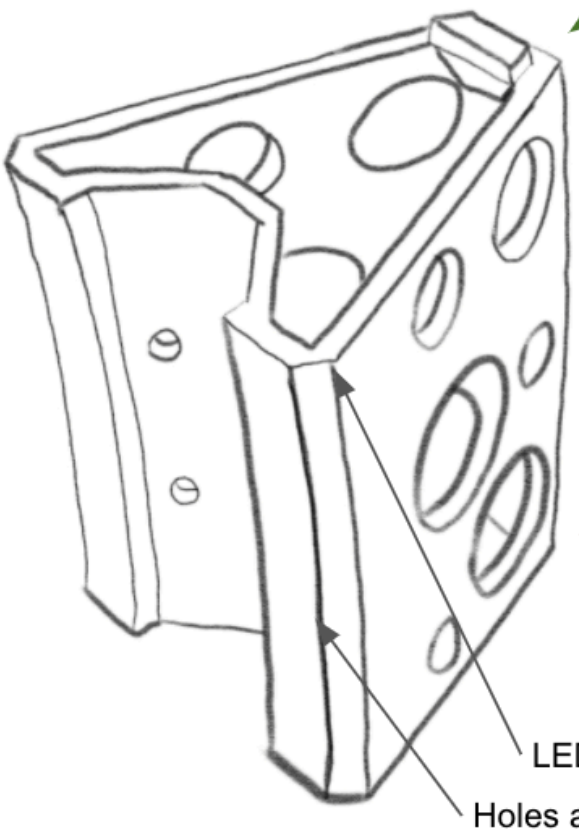
(Spec 4.1) Inefficient use of materials, without holes to reduce amount of materials used

USER FEEDBACK - Arc Segment

(Spec 5.2) “It seems to lack adjustability and hard to disassemble”

(Spec 2.3) Attaching LED strips inside makes it less prone to falling, increasing product lifetime

Arc Segment 2



USER FEEDBACK - Arc Segment

(Spec 2.1) “Adjustability of size and shape make it suitable for many workspaces”

(Spec 6.4) “Glue adhesives may be insufficient to safely hold arc segments“

(Spec 4.1) “I’d reduce amount of material used, making it more eco-friendly”

(Spec 2.1) “I’d make components more easily disassemblable to increase recyclability”

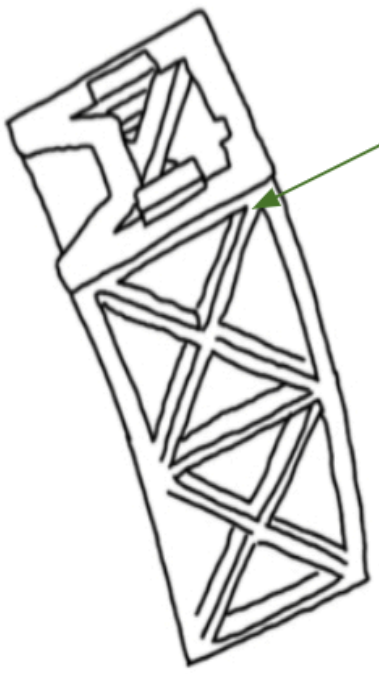
(Spec 4.1) Reduced amount of material making it a more eco-friendly product

(Spec 7.1) Holes may be insufficient to provide bright enough illumination

Arc Segment 3

(Spec 6.4, 7.4) Safety joints printed with each arc segment provide greater stability

(Spec 4.2) Made out of composable components making it easy to disassemble



USER FEEDBACK - Arc Segment

(Spec 6.1) “Maintains high safety standards due to cross linking poles”

(Spec 4.2) “Use of joints increases stability and ease of disassembly”

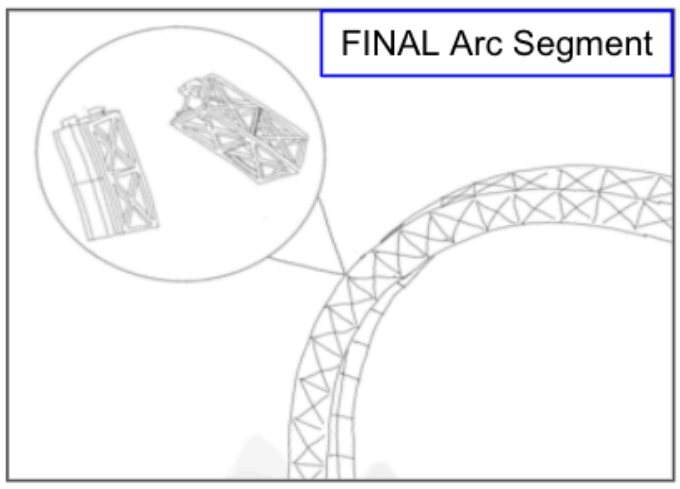
(Spec 9.1) “Has efficient use of material”

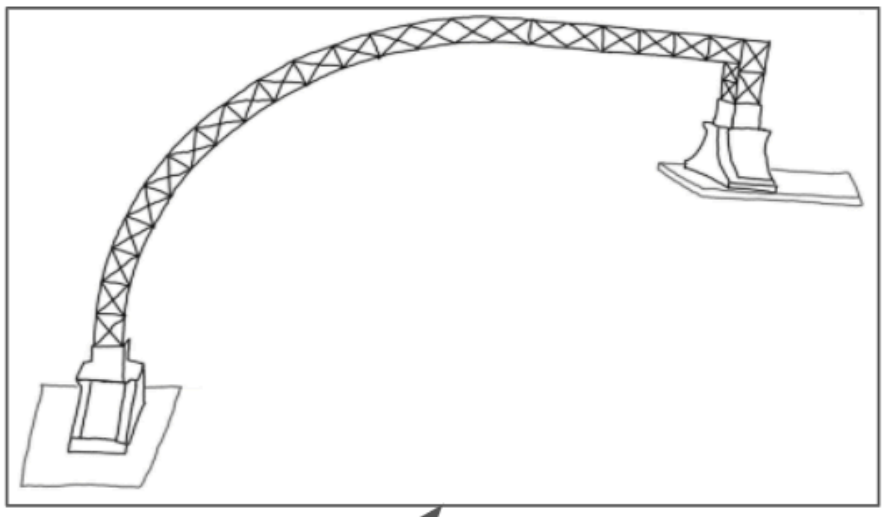
Arc Segment Modifications Selection (3rd) Overview

Inspiration was taken from New River Gorge Bridge in USA:

Bridge had a very similar arc-like structure

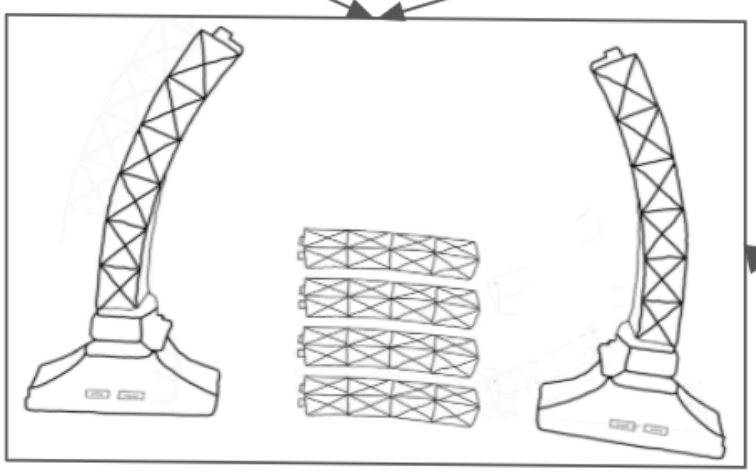
FINAL Arc Segment





Cross shaped arc segments

Allows for minimization of materials used without sacrificing safety (User 3)



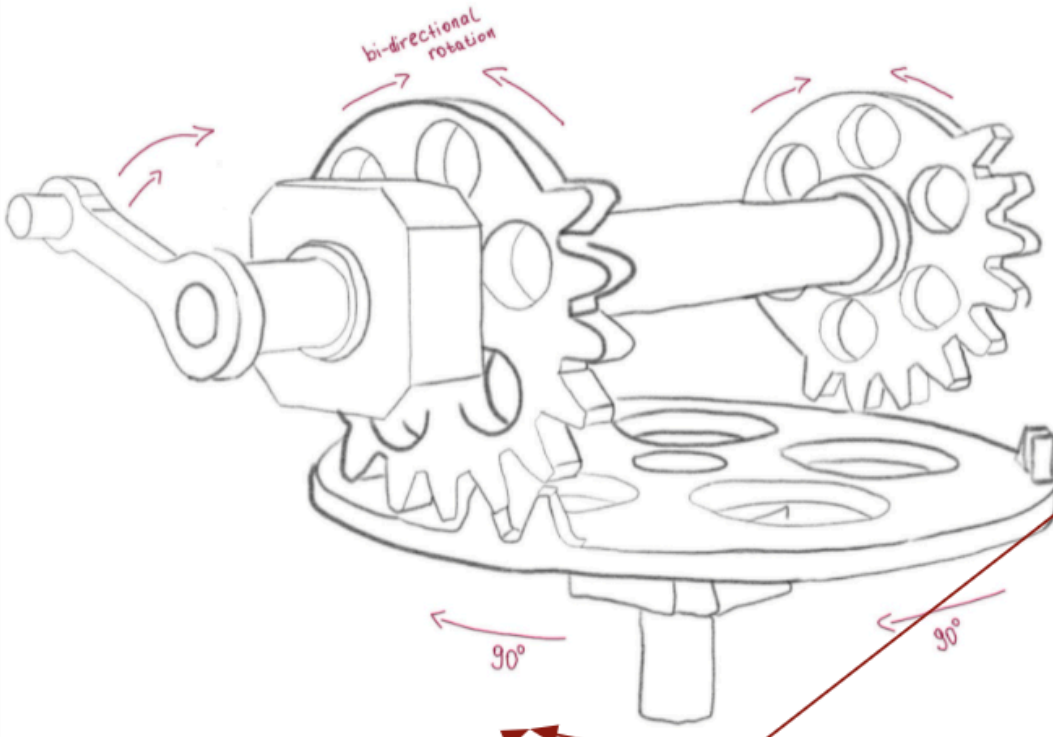
(Spec 5.2) Allows wide range of shapes by 3D printing more arc-segments

(Spec 5.2) Suitable for wide range of workspaces due to excellent adjustability

(Spec 5.2, 4.2) Disassemblable arc-segments increase product's suitability for wide range of workspaces

Rotating mechanism for light direction adjustability Modifications and Selections

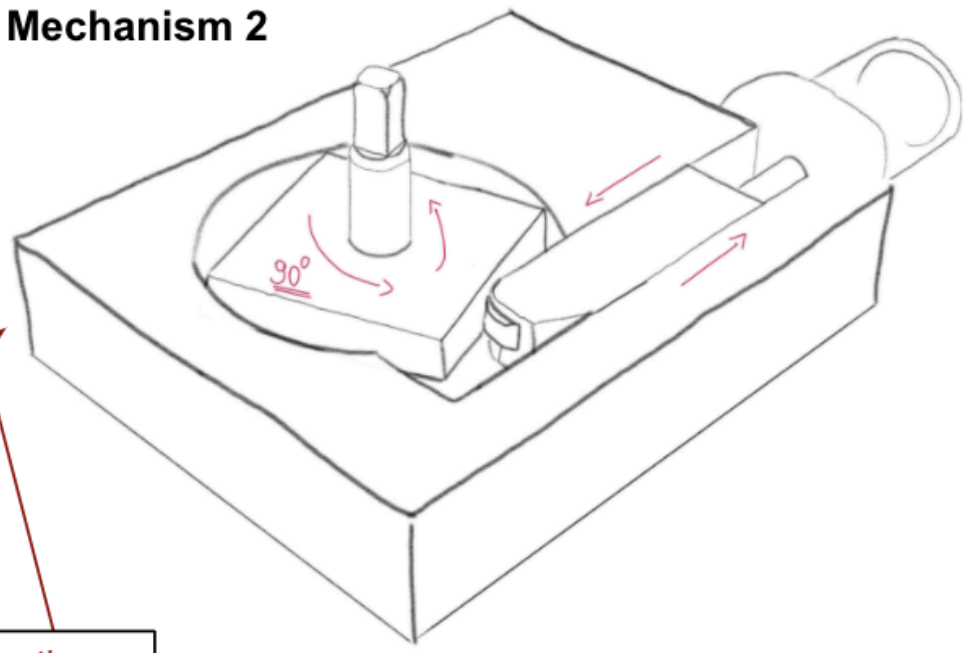
Mechanism 1



USER FEEDBACK

(Spec 7.4) “Unadjustable light direction limit task specific illumination to ensure productive work”

Mechanism 2



(Spec 8.1) Complex construction increasing manufacturing time

USER FEEDBACK

“Compact structure of 3rd mechanism fits well with product’s aesthetics”

“3rd mechanism has greater range of rotation (180°) than other mechanisms”

(Spec 5.1) “Large mechanisms are space consuming, so unsuitable for constrained workspaces”

(Spec 5.1) Compact size making it suitable for constrained workspaces

(Spec 7.4) Limited rotation. Only rotatable by 90°

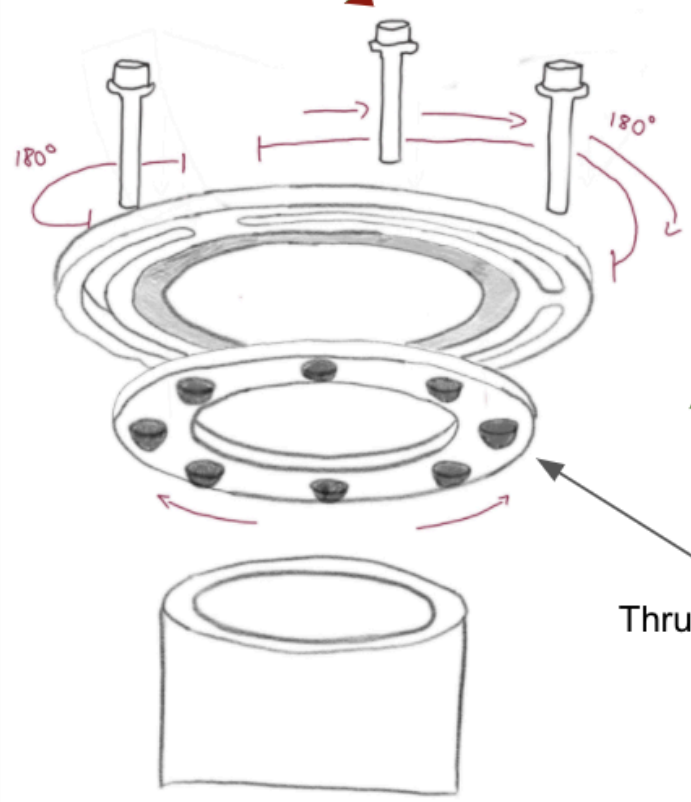
Easily manufacturable components with CAD/CAM increases speed (Spec 8.1) and minimises wastage (Spec 8.3)

Circular base shape may not fit well all workspaces (Spec 1.1)

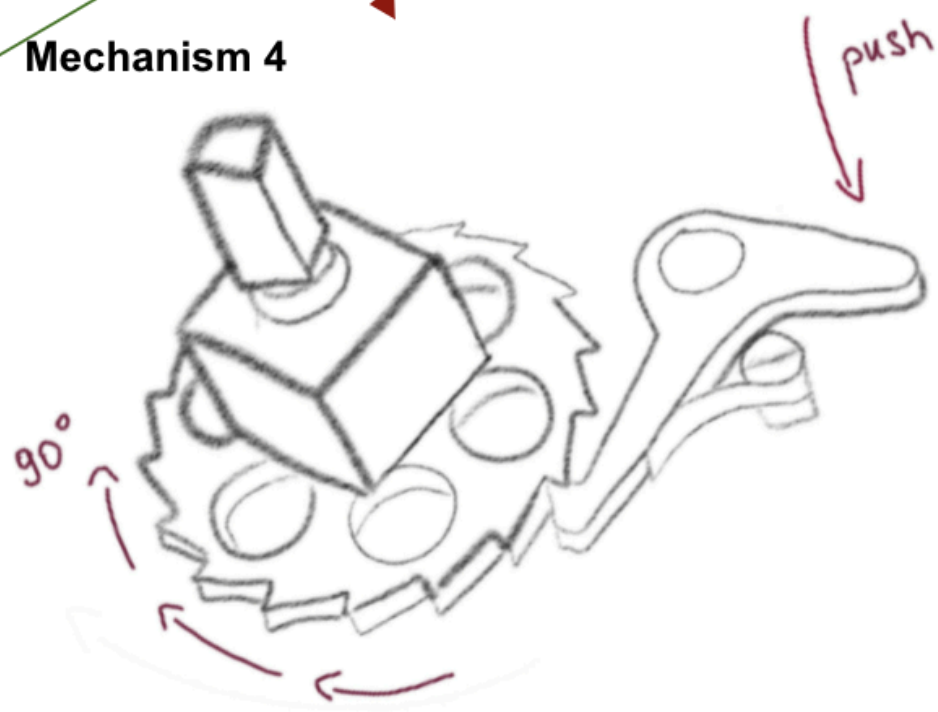
(Spec 4.2) Easily disassembled allows for simple repairment and replacement of components

(Spec 7.4) Rotation range of 180°

Mechanism 3 (selected based on user feedback)

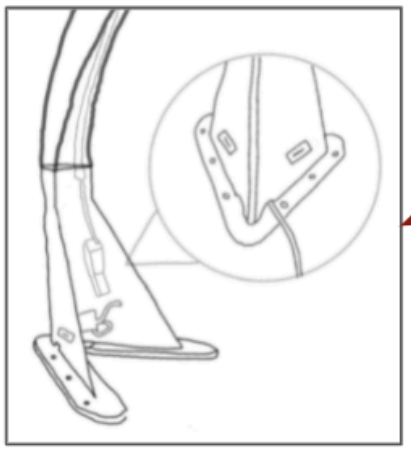


Mechanism 4



Foot Base Modifications and Selection

Base 1 - Original base

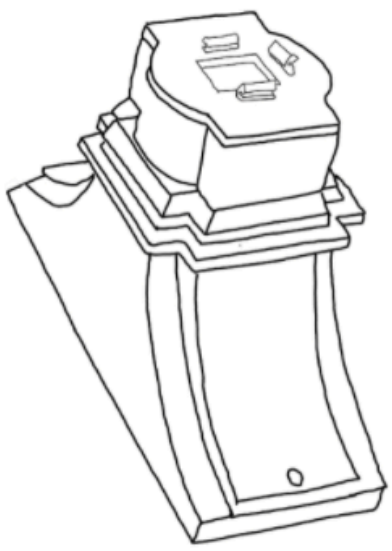


USER FEEDBACK - Foot Base

(Spec 6.1) “Cables of USB-ports and LEDs are exposed, increasing injury risks”

(Spec 6.4) “Bases seem unstable, making lamp unsafe and risky to use”

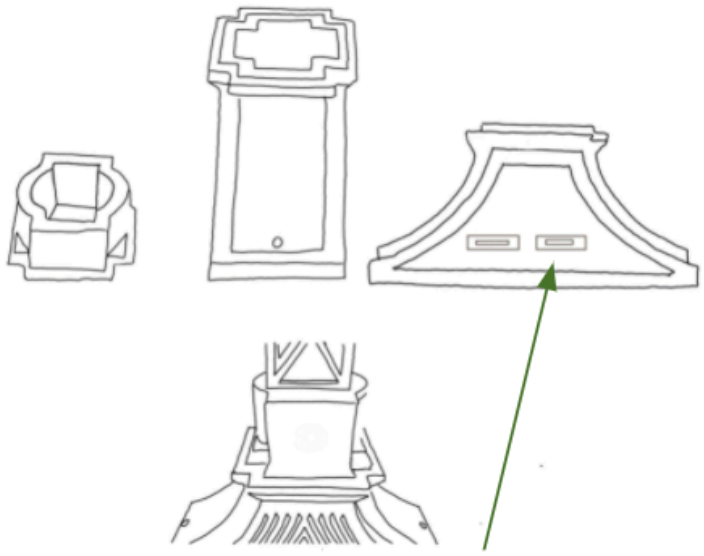
Base 2 - Base for mechanisms 1, 2 and 4



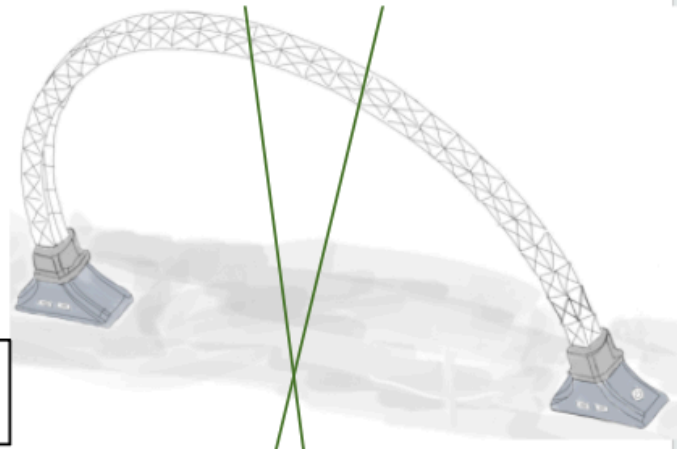
(Spec 6.4) Holes for screws to increase stability of the construction

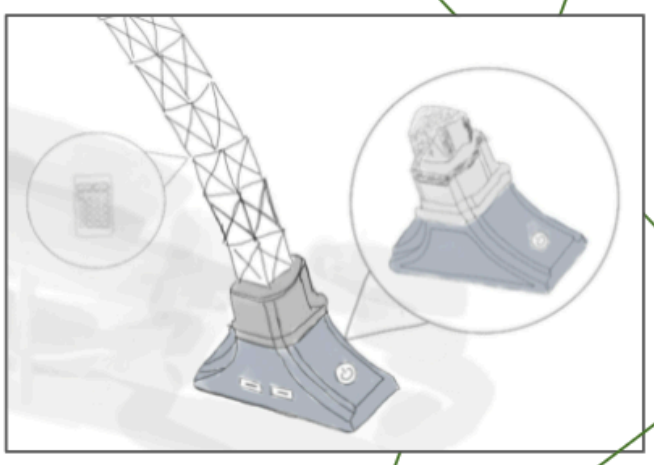
(Spec 4.1) Ventilation design decreases the amount of material for manufacture

Easily disassembled components of increase recyclability (Spec 4.1) and increase production sustainability



Possible construction of final product with this foot base





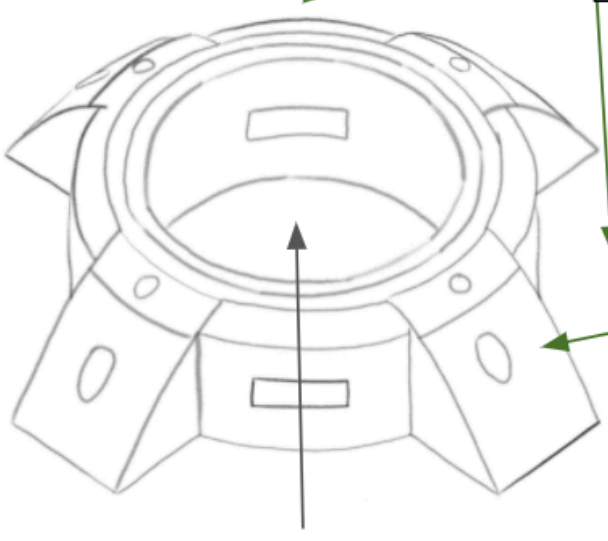
(Spec 6.4) Increased bottom surface area makes lamp more stable increasing safety

Greater volume allows more USB-ports integration and hide their electronics (User 4)

(Spec 6.1) Greater volume provide space to hide electronics to avoid injuries

Ventilation to make lamp less prone to fire - increasing safety (Spec 6)

Base 3 - Base for mechanism 3 (selected based on user feedback)



(Spec 8.1) Pre-designed holes allow easy screwing to the desk - increasing stability

(Spec 2) Four sub-feet allow for greater stability and safety

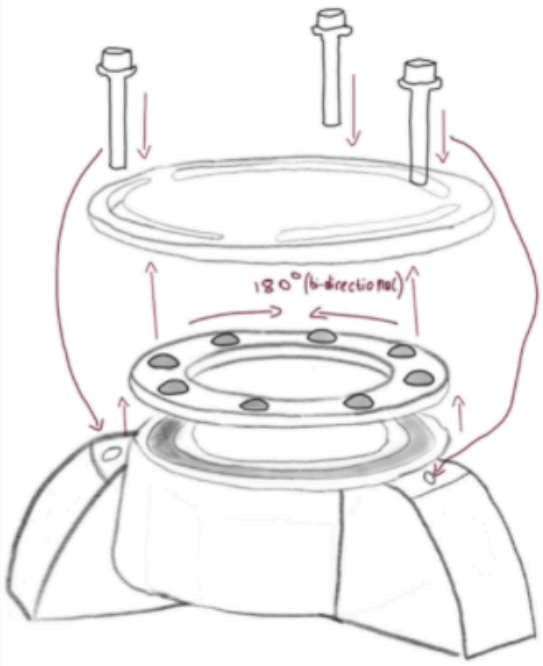
USER FEEDBACK - Foot Base

“2nd and 3rd bases seem suitable as they solve all limitations of 1st”

“However, since circular mechanism was chosen, 3rd base will be most suitable”

Wires will be stored inside and covered by rotational mechanisms

Foot base with Rotation Mechanism Selection Overview



(Spec 4.2) Easy to disassemble

No joints present to attach the arc-segment

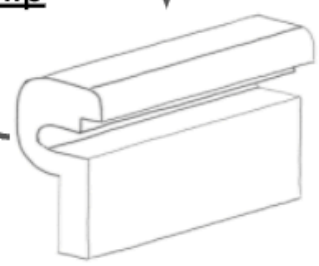
Opened bottom make cables stored inside prone to breaking during transportation

3D printed thrust bearing allows top platform to rotate by 100°

Foot base improvements

3 clips are inserted in top-plate's slots to align arc-segment

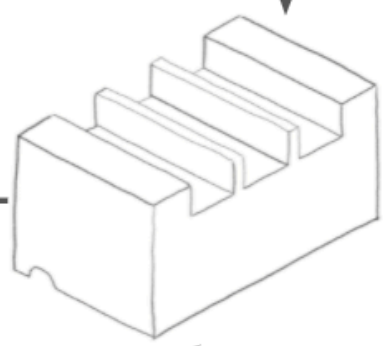
Clip

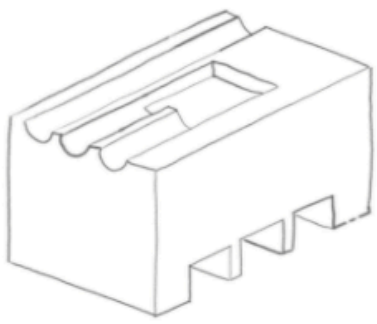


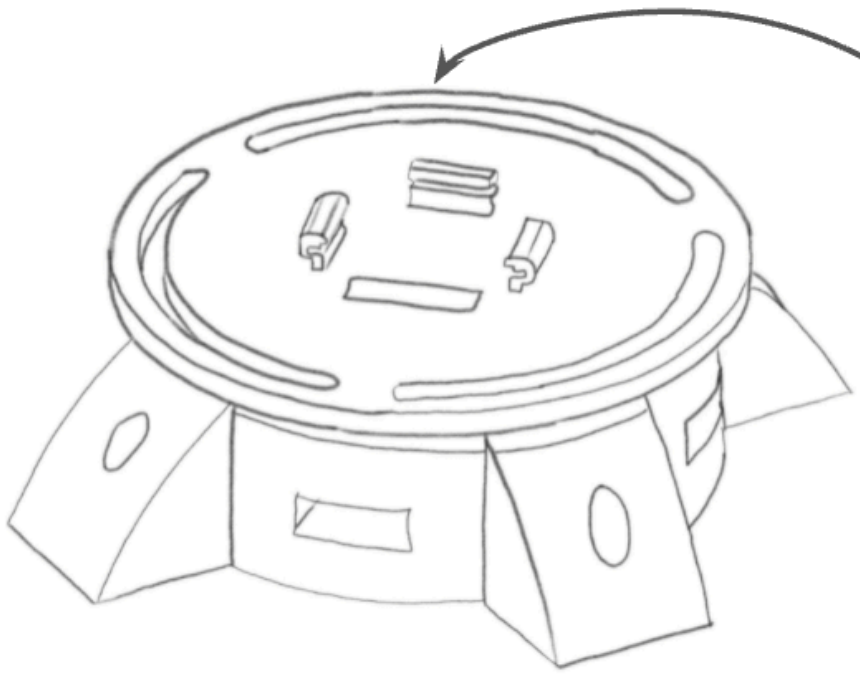
Strain-relief prevents strain on the solder joints of the LED-strip

Strain-relief's bottom has channels for leads of LED-strip

Strain-relief



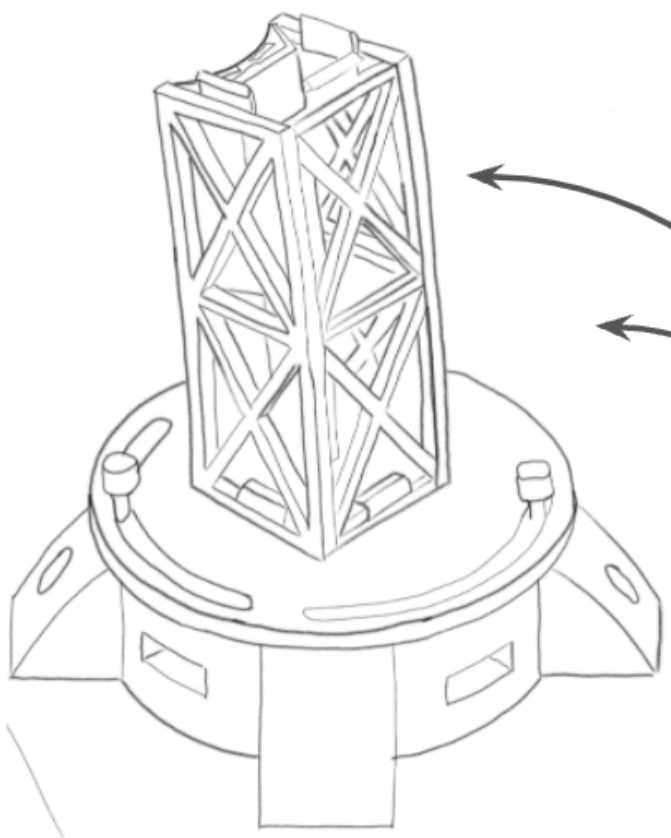




Strain-relief contains resistor and capacitor to use it with LED-strips

Epoxy resin applied to strain-relief and placed over LED-strip's wires

Final Product (default shape)

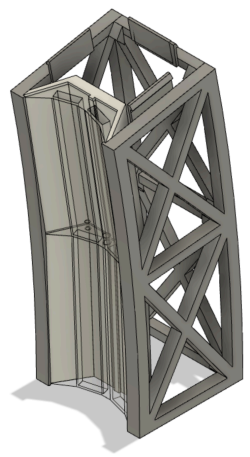
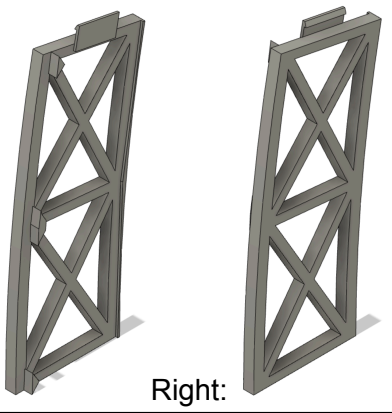
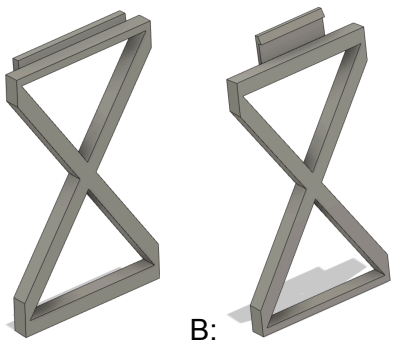
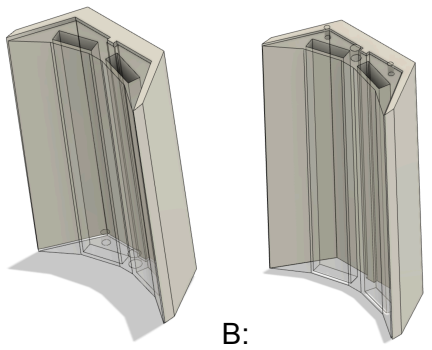
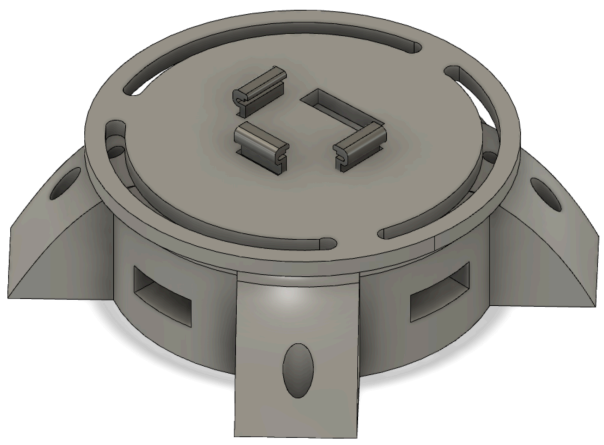
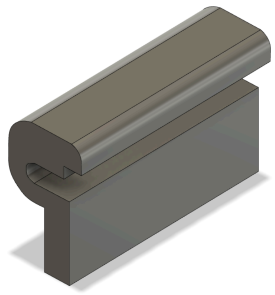
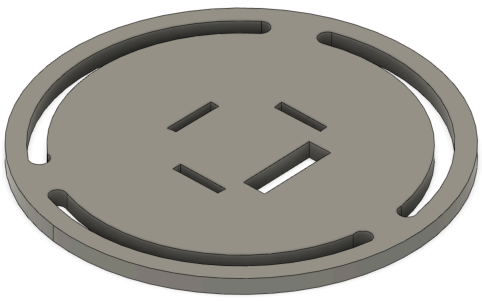


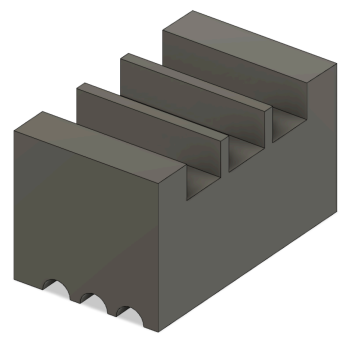
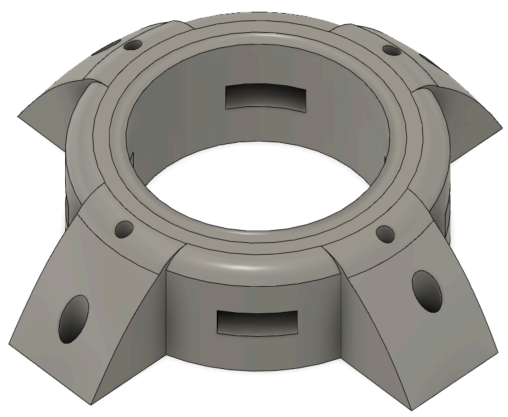
Arc Segment

Foot base (with rotation mechanism)

Criterion C

1. Materials and processes with justification for selection (340 words)

Component List			
Component name	**Material**	**Manufacturing process**	**Image**
Arc-segment	PLA	FDM 3D Print	
- Sidewall left and right			 Left: Right:
- Top wall A and B			 A: B:
- Bottom LED holder A and B			 A: B:
Foot base			
- Clip / x3			
- Top plate			

- Strain relief			
- Bearing cage			
- Base			

Materials for 3D-Printed components			
Characteristic	**PLA**	**ABS**	**TPU95A**
Mechanical properties	Durable and tough,but not as tough as ABS & may become brittle = 4	Strong, tough and durable = 5	High impact strength Resistant to wear and tear = 5
Physical properties	Easy to print. Low particle emissions so fit for housekeeping and repeated usage (F7) = 5	Easy to print = 4	Easy to print = 4
Cost	18.18€ for 1kg, 1.75mm = 5	18.18€ for 1kg, 1.75mm = 5	57.97€ for 1kg, 1.75mm = 3
Availability	Readily available in Spain and in school workspace = 5	Readily available in Spain and in school workspace = 5	Readily available in Spain but not in school workspace = 3
Finish required	Yes. Remove support material and treat with acetone to smoothen = 3		Yes. Remove support material = 3
Environmental considerations	It is made out of corn starch - 5	It is made out of thermoplastic - 3	It is made out of thermoplastic - 3
Aesthetic properties	Printed with high resolution, surface quality and different colours (Spec-5.7). Glossy finish can be done (Spec-5.1) = 5	Printed with different colours (Spec-5.7) Matte finish can be done (Spec-5.1) = 4	Relative to other materials, it lacks aesthetic properties = 3
Totals	**32/35**	**29/35**	**24/30**
PLA is select as the best material for printing components			

Justification: PLA was chosen as the material for 3D printing. Though it scored the highest alongside ABS, PLA was chosen for its attractive (glossy finish) aesthetics and safe (high surface quality) suitable for households (Spec-5, F7). It is a low production cost material with high impact and scratch resistance, as well as lightweight which is vital for transportation purposes and multiple uses. Furthermore, PLA has low particle emission, important for housekeeping in case of users consuming food near the lamp. PLA is durable enough to withstand human compressive force (Spec-5.9). PLA is not waterproof, however, it can be finished to be water-resistant (Spec-5.5). Furthermore, it is inexpensive (Spec-4.2), available and easily machined.

Feasibility of manufacturing processes			
Characteristic	**FDM 3D printing**	**Hand / Machine tools**	**Laser cutting**
Complexity	Complex shapes in xyz-axes - 5	Complex shapes (in xyz-axes) - 5	Complex shapes in xy-axes, layers needed for z-axis - 3
Cost	Considerable initial startup cost. Materials may be expensive - 3	Can be inexpensive - 5	High initial startup cost; low unit cost - 3
Skill required	High level of skill required to create the designs (CAD) - 3	Extremely high level manual workshop skills required - 1	High level of skill required to create drawing - 3
Availability	3 3D printers available - 5	Available workshop and abundant tools - 5	1 Laser Cutter available - 3
Repeatability	Can easily produce parts repeatedly once programmed - 5	Difficult to reproduce parts exactly the same - 2	Can produce same parts repeatedly once programmed - 5
Accuracy	High accuracy - 5	Due of the human error element, accuracy is limited when compared to CAM - 2	High accuracy - 5
Finish	Post-manufacturing finishing is usually required to remove supports - 2	In most cases, finishing is necessary - 2	High quality; no post-manufacturing finishing needed - 5
Waste	There is relatively little waste produced by additive manufacturing - 5	It's likely to generate a lot of waste - 2	Need to tessellate shapes on sheet to reduce waste - 2
Materials	There are several varieties of plastic available. - 4	Very wide range of materials available, including: wood, metals, and polymers - 5	Sheet materials: Polymers, maximum 7mm thick; Timber, maximum 5mm - 1
Time	Printing can take a long time. - 3	Producing a component takes a lengthy time - 1	Cuts quickly once programmed - 4

Totals	**40/50**	**30/50**	**34/50**
FDM 3D printing is selected as most appropriate for the product			

Justification: 3D Printing was chosen for manufacturing not only because it scored the highest, but also because the alternative hand or machine tools wouldn't be practical, as it would take too long to produce the complex components. Whereas FDM 3D-printing does this in a much shorter time, to an excellent degree of accuracy and minimal waste (Spec-7.3, F16). High degree of accuracy will ensure that the prototype is of high fidelity and it can be used to gather data for successful evaluation.

Feasibility of joining processes				
Characteristic	**Adhering**	**Soldering**	**Screwing**	**Fusing**
Accuracy	Surfaces are manually adhered, which may reduce precision - 3	Surface are manually soldered, which may reduce precision - 3	Holes and marks created by FDM printing, hence highly accurate - 5	Surfaces are manually adhered, which may reduce precision - 3
Cost	Very inexpensive - 5	Expensive - 3	Very inexpensive - 5	Tools required can be expensive - 3
Skill required	Experience with adhesion is required - 4	Preparation & soldering process with protecting equipment requires professional skills - 4	Skills required to mark & create holds - 4	Skills required to operator fusing tools safely and accurately - 3
Availability	Very available in Spain in local shops - 5			Available in Spain with multiple local shops - 4
Suitability for chosen material	Suitable for permanently joining the arg segment components - 5	Suitable for assembling electronic components and securely joining them together - 5	Temporary joints allow design for (dis)assembly of components - 5	Fusing isn't required, and simpler joining methods are sufficient - 5
Totals	**22/25**	**20/25**	**24/25**	**18/25**
Screwing, adhering and soldering are selected as the most appropriate for the product.				

Justification: Adhering with glue will be applied to arc-segments and LED strips with the bottom sides of the arc-segments. Screwing will be used to attach the foot-bases to the table/workspace to ensure stability and safety of the construction without permanently joining it (for design for disassembly). If any footbase or its inner electronics needs replacement, the screws can be easily removed and the product can be completely disassembled, components replaced, and the product can be put back together again. Soldiering makes it possible to assemble electronic components. The wiring has to go through the whole product connecting the LEDs and the USB ports in the bottom part. Adhering, screwing and soldering scored the highest.

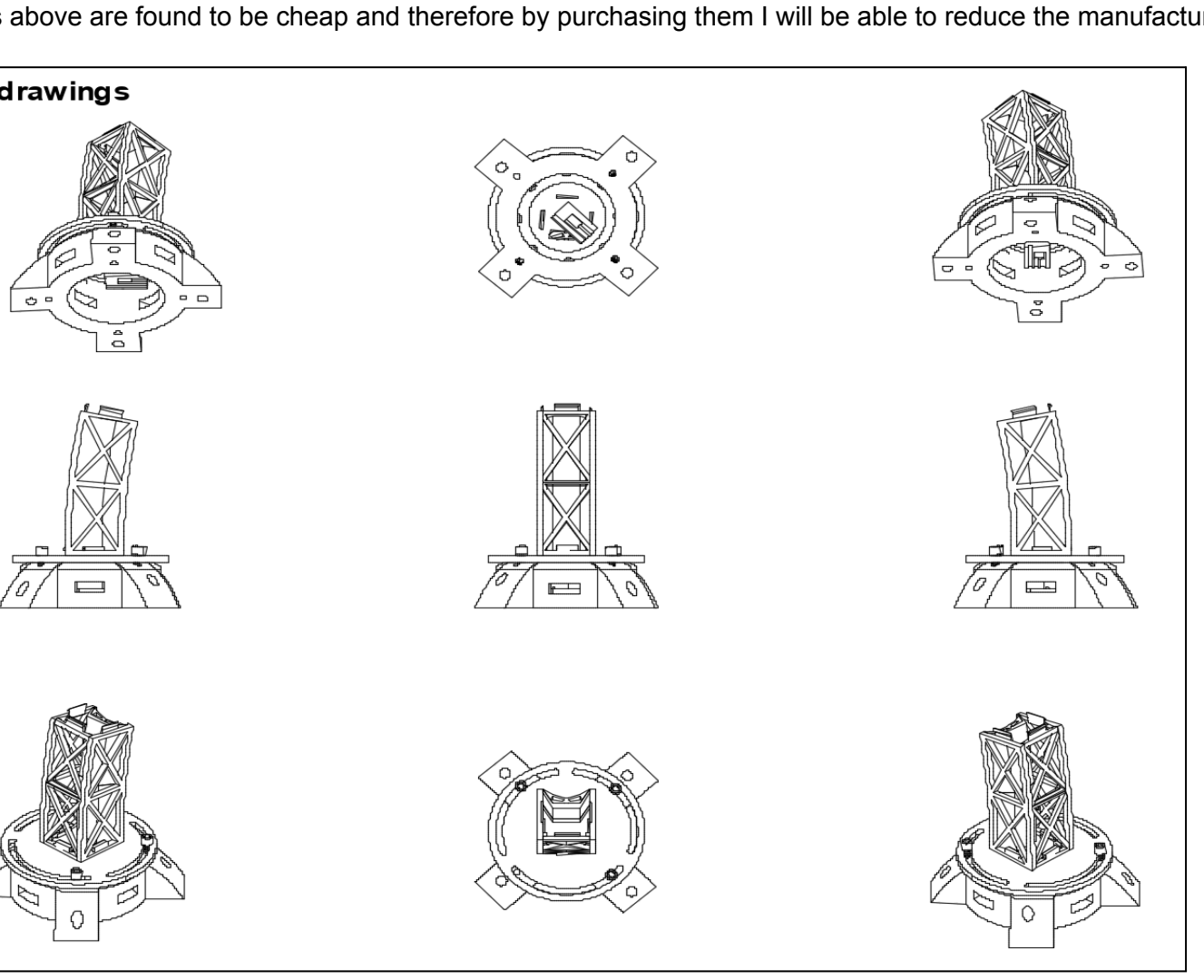
Component list for purchase

Component considerations								
	Ball bearing (9.1 mm)	**Epoxy resin**	**LED strips (with colour/intensity adjustability)**	**USB ports**	**USB C connector**	**Wires**	**Anodized screws**	**M5x30 Bolts and washers**
Aesthetic properties	Shiny and appealing	Transparent, so no aesthetics are harmed	Technological aesthetics suits the aesthetics of an innovative lamp			Will be hidden, so aesthetics don't matter		It's not aesthetically pleasing, but form has to be sacrificed for function
Functional properties	Rounded surface allows for smooth rotational effect	It is highly durable	High quality and efficient illumination of the workspace	Efficient and widely accepted making it suitable		Safe and efficient for energy transmission with minimal losses	Structure allows for secure holding and easy screwing	Structure allows for secure holding & easy sinking
Cost	Cheap (1.6€/)	Cheap (5€/280ml)	Cheap (10€/5m)	Cheap (2€/piece)		Cheap (0.36€/metre)	Cheap (0.14€/piece)	Cheap. Bolt (0.14€/item) Washer (0.11€/item)
Availability	May be difficult to find this specific dimensions	Widely available						
Environmental considerations	It's environmentally friendly as it's made of high carbon chromium steel	It's completely inert once catalysed & thus environmentally safe	LEDs use relatively little energy, hence placing less demand on natural resources	-	It' made of 35% biodegradable materials	Most wires contain no halogens, phthalates or heavy metals	Anodizing is an environmentally friendly metal finishing process with no hazardous waste created	It's environmentally friendly, as it's made of stainless steel
Relevance to the user's needs	To fix bolts of the plate, ensuring stability & allow plate movement	Stick components together to ensure stability & safety of the construction	To provide energy efficient light output with minimum power consumption & heat emission	Will provide a charging hub, aiding reduction in workspace clutter of user	Will connect the power supply with the lamp	Will be used as the channel for electricity transmission between electronic components	Screws are used for holding the foot-bases with the table	Bolts are used for holding the top Plate to allow rotation of the base.

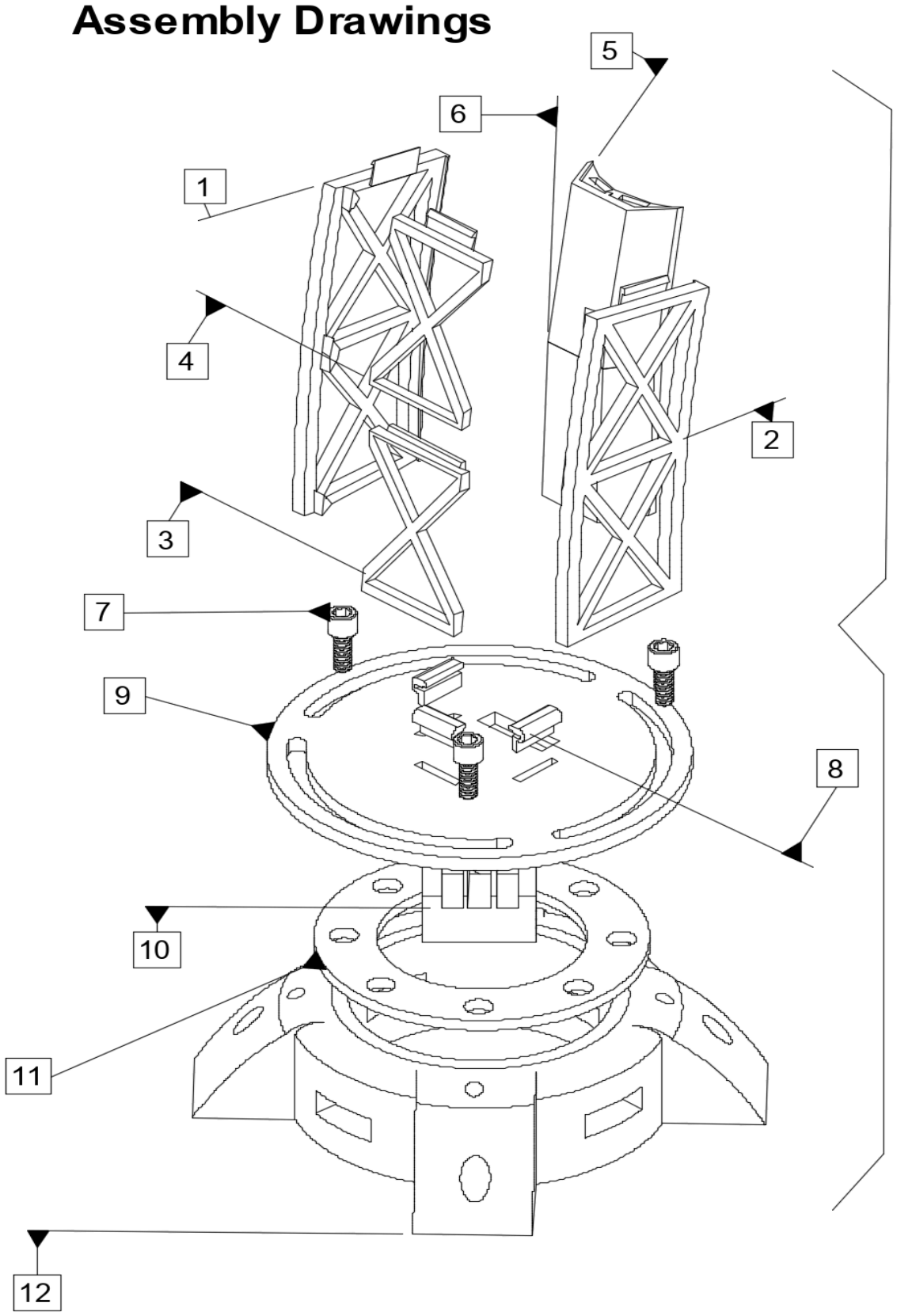
Justification: All of the components above are found to be cheap and therefore by purchasing them I will be able to reduce the manufacturing costs and time.

2. Developing a Design Proposal

Isometric drawings
Scale: 1:3



Assembly Drawings



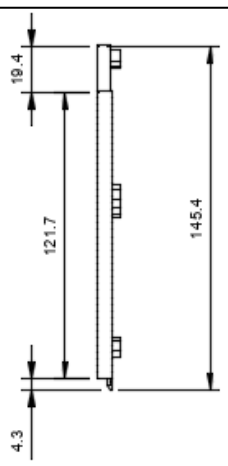
Arc segment components

Item	Part name	Qty.
1	Side wall left	1
2	Side wall right	1
3	Top wall A	1
4	Top wall B	1
5	Bottom LED holder A	1
6	Bottom LED holder B	1
7	M5x30 Bolt (purchased)	3

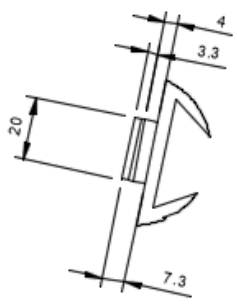
Foot base components

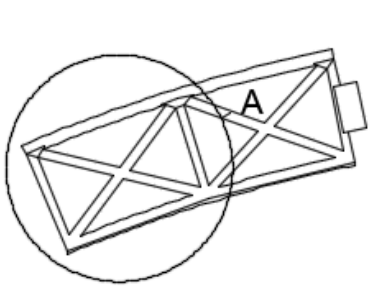
Item	Part name	Qty.
8	Clip	3
9	Top plate	1
10	Strain relief	1
11	Bearing cage	1
12	Base	1

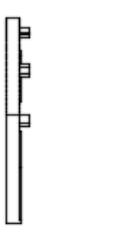
Title: Side wall
Units: cm
Scale: 1:2

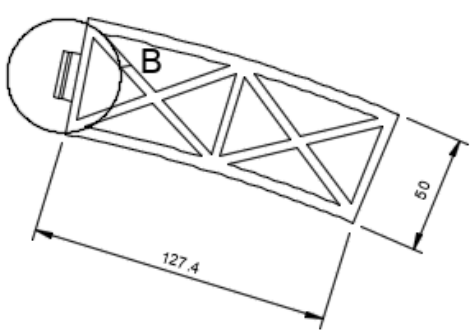


B: Lateral joint (1:1.5)

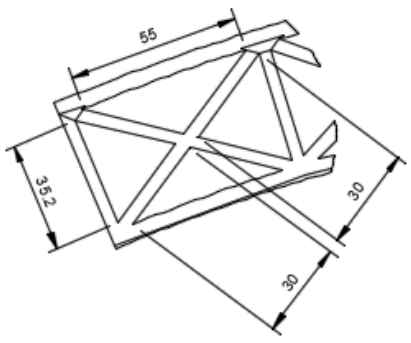


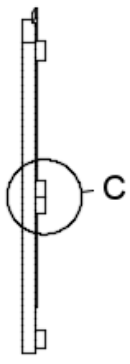




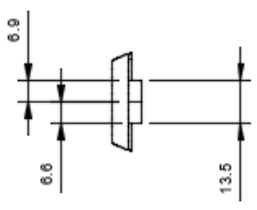


A: Crossed section (1:1.5)

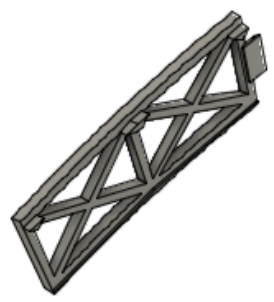




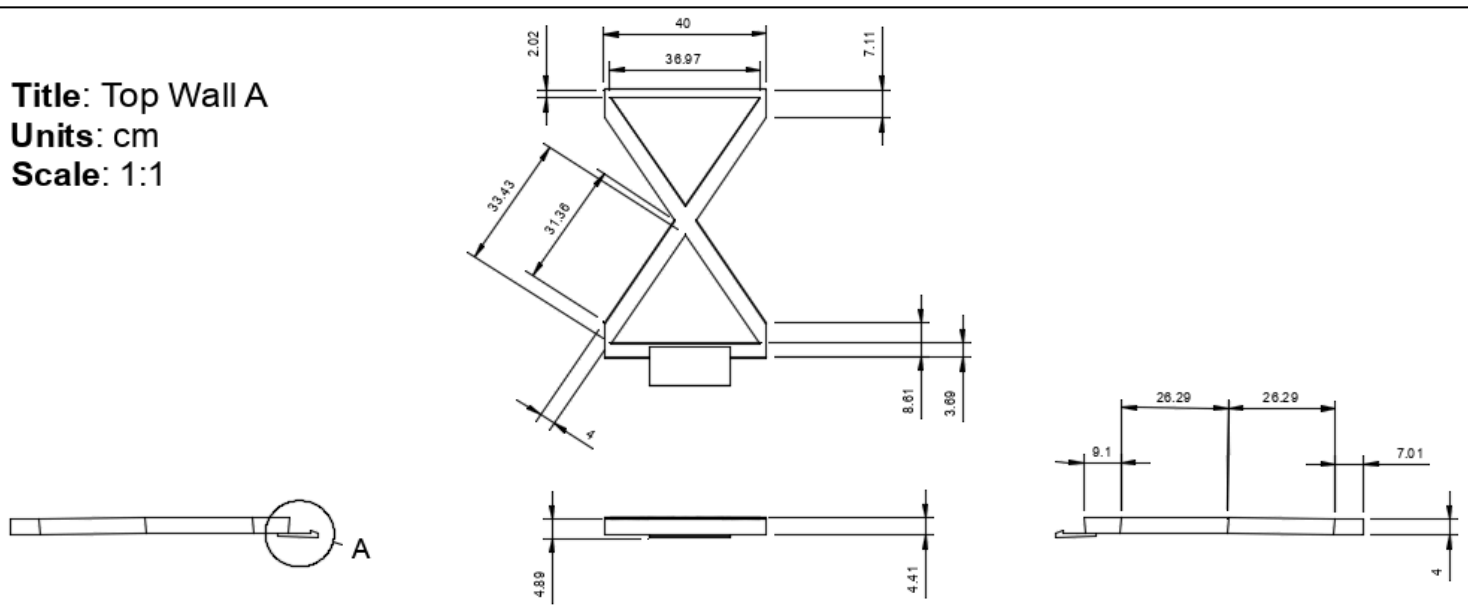
C: Side joint (1:1.5)

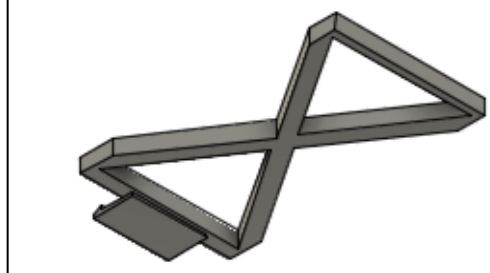


Title: Side wall
Units: cm
Scale: 1:2

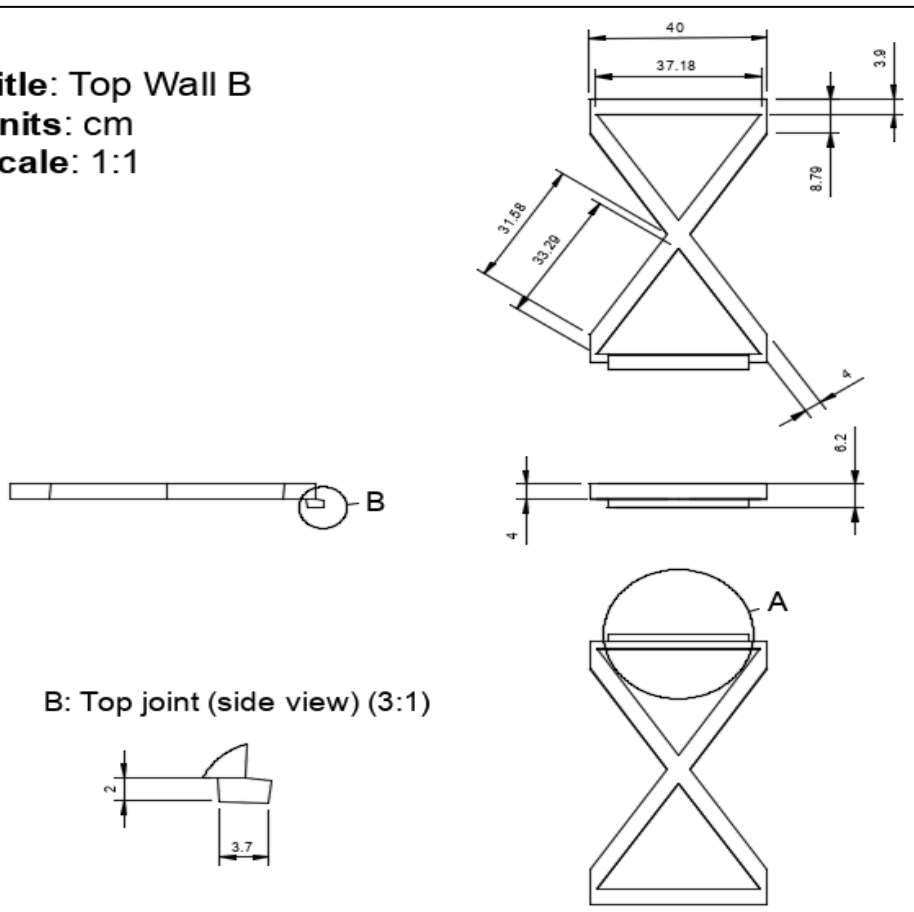


Title: Top Wall A
Units: cm
Scale: 1:1

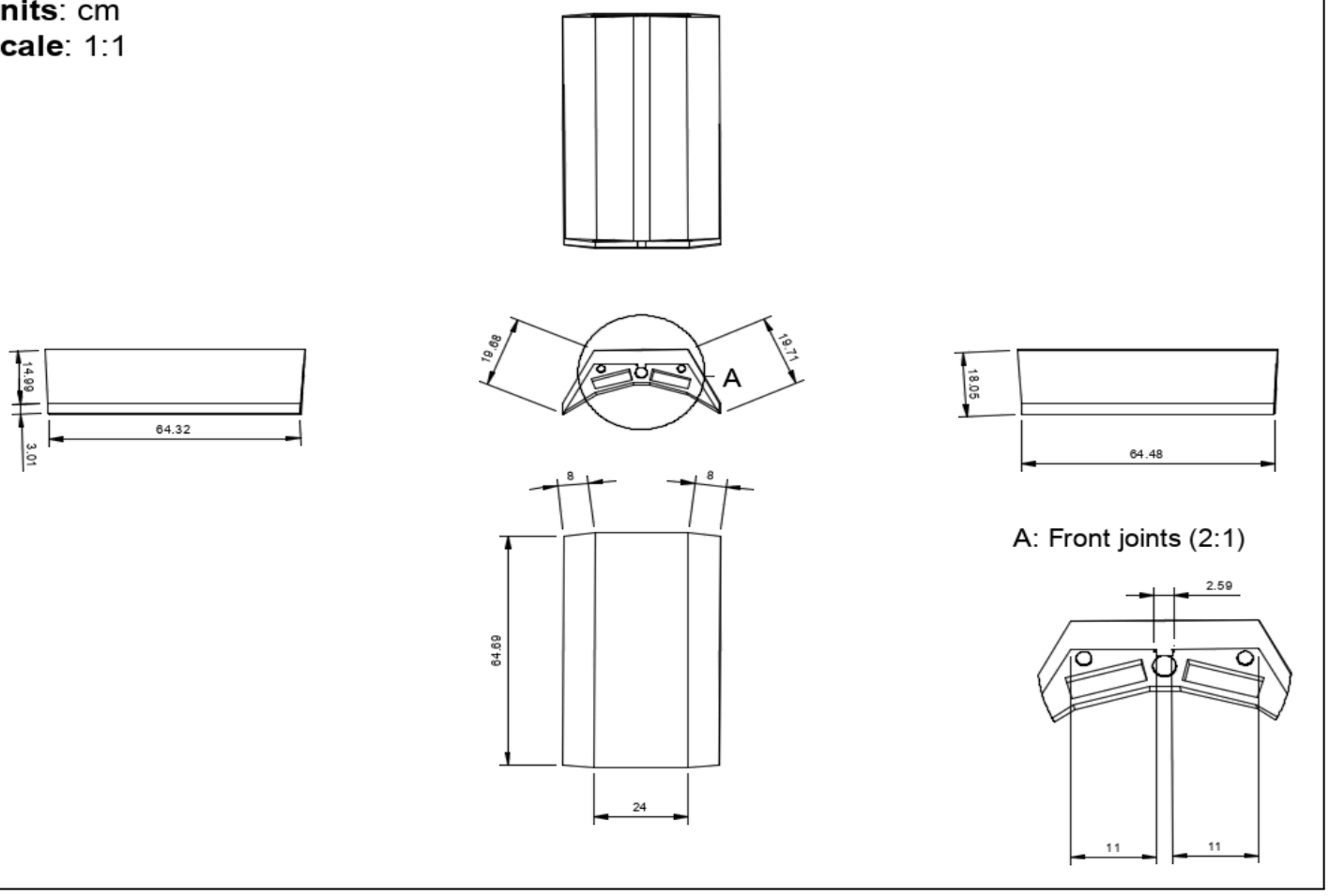


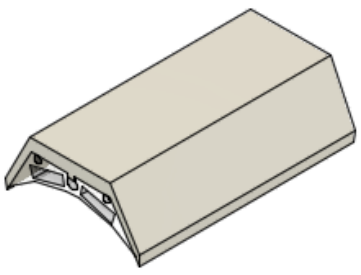


Title: Top Wall B
Units: cm
Scale: 1:1



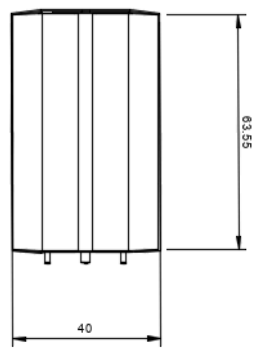
Title: Bottom LED holder A
Units: cm
Scale: 1:1

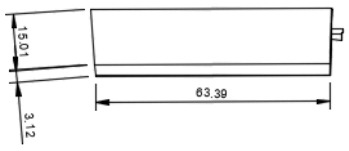


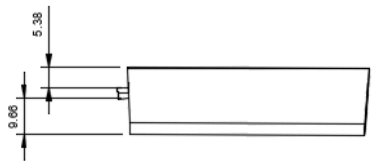


Title: Bottom LED holder A
Units: cm
Scale: 1:1

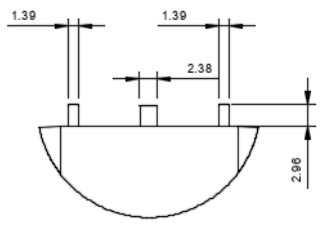
Title: Bottom LED holder B
Units: cm
Scale: 1:1

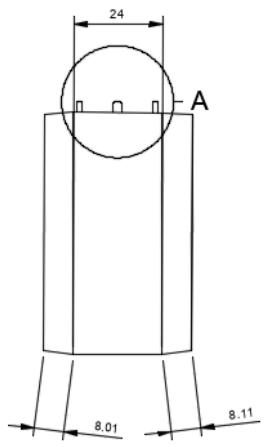




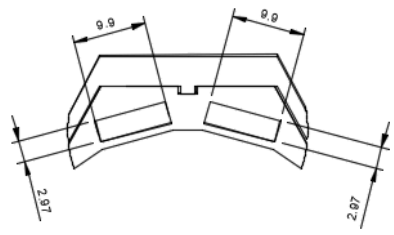


A: Front joins (2:1)

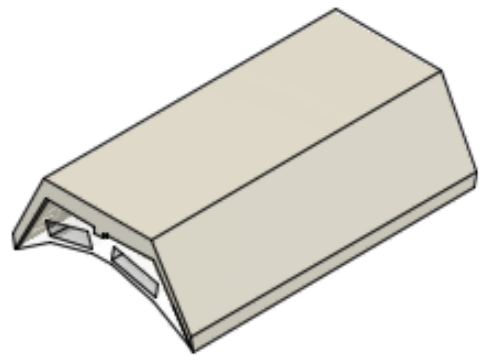




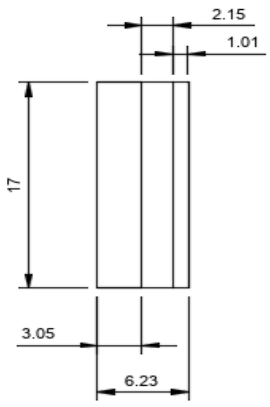
B: Tubes for cabels (2:1)

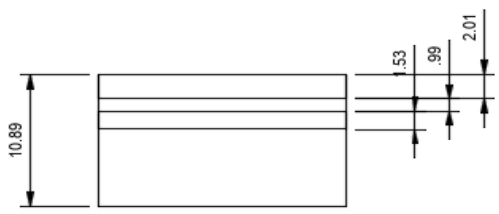


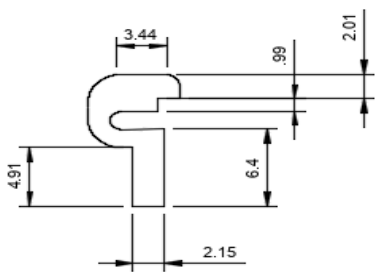
Title: Bottom LED holder B
Units: cm
Scale: 1:1

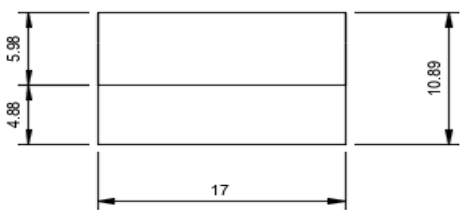


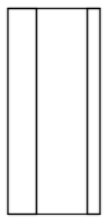
TItle: Clip
Units: cm
Scale: 3:1



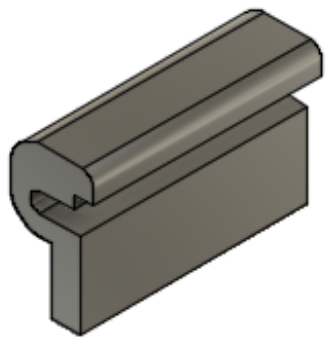




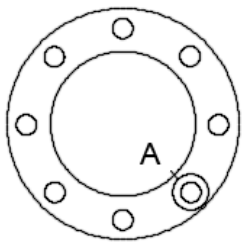




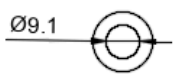
Title: Clip
Units: cm
Scale: 3:1

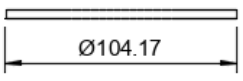


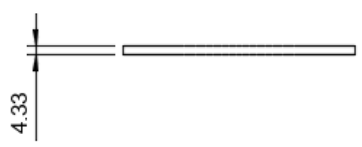
Title: Bearing cage
Units: cm
Scale: 1:2

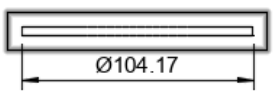


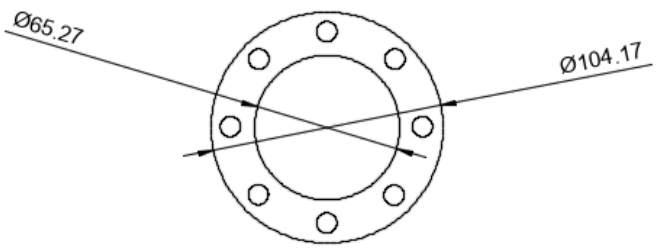
A: Hollow circle for ball bearing of 9.1 cm (1:1.2)





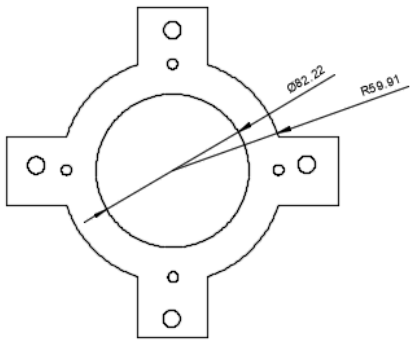




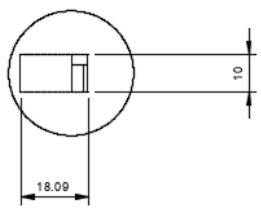


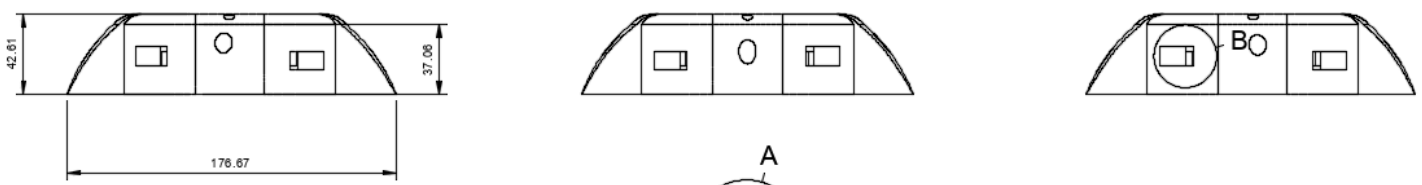
Title: Bearing cage
Units: cm
Scale: 1:2

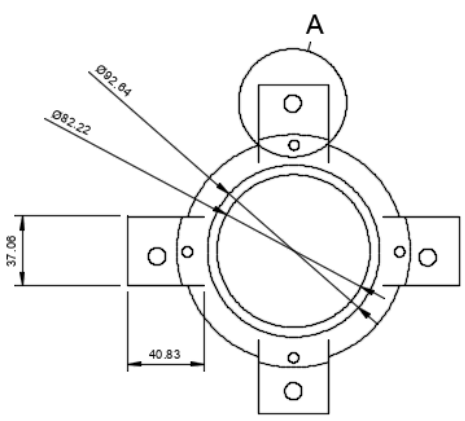
Title: Base
Units: cm
Scale: 1:2



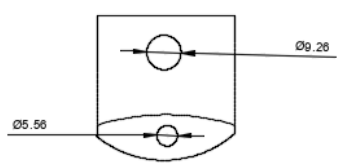
B: Hole for a USB port (1:1)



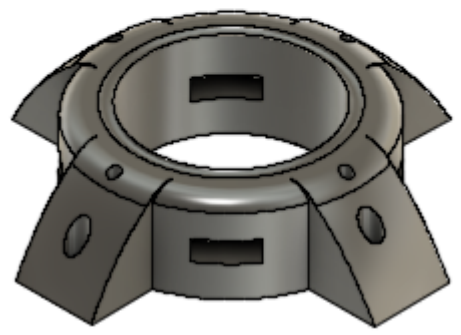




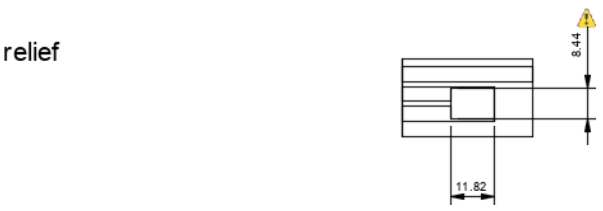
A: Base holes for screws (1:1)



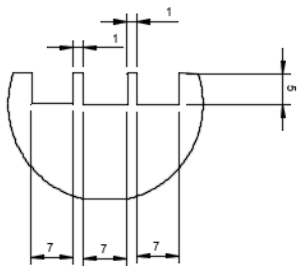
Title: Base
Units: cm
Scale: 1:2

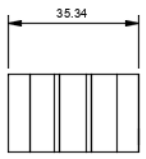


Title: Strain relief
Units: cm
Scale: 1:1

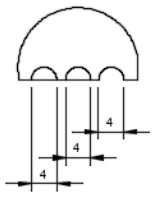


A: Top segments division (1.7:1)

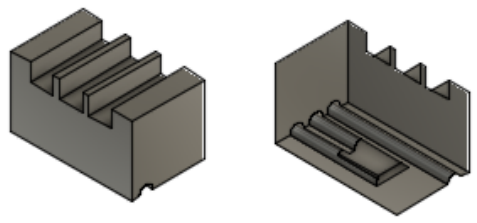




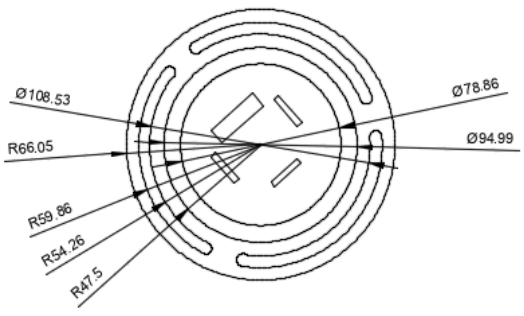
B: Bottom runnels for cables storage (1.7:1)

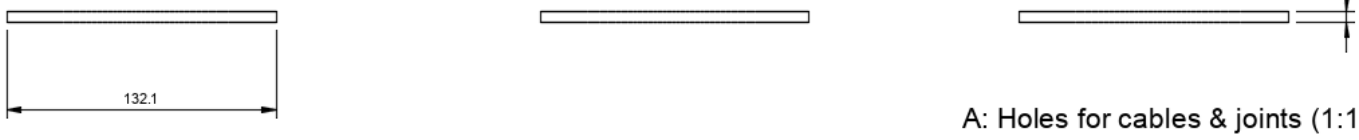


Title: Strain relief
Units: cm
Scale: 1:1

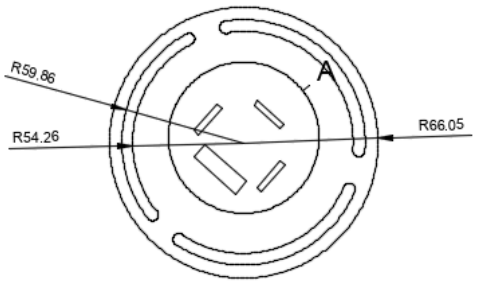


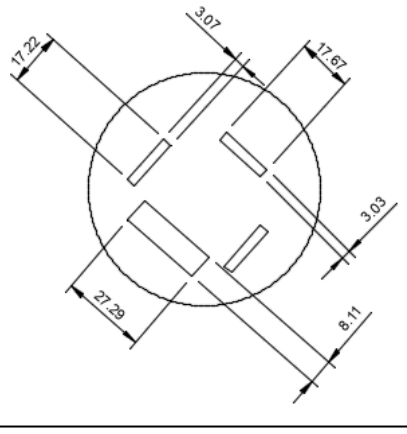
Title: Top plate
Units: cm
Scale: 1:2



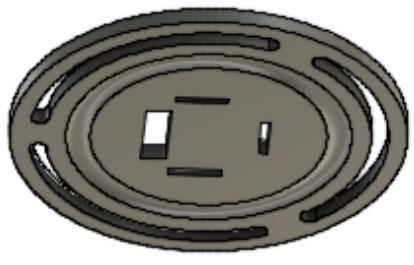


A: Holes for cables & joints (1:1.3)





Title: Top plate
Units: cm
Scale: 1:2



Bill of Materials

Component	Material	Size / per piece	Qty.	Cost	Finish	
3D printer and laser cut components						
Arc Segment	Polylactic acid (PLA)	30g	1 x 30g	1kg = 17.87 0.256 kg (total PLA required)	Remove support material: can treat with acetone to smoothen surface	
- Sidewall right		16g	1 x 16g			
- Sidewall left						
- Top wall A		4g	1 x 4g			
- Top wall B						
- Bottom LED holder A		10g	1 x 10g			
- Bottom LED holder B						
Foot base		226g	1			
- Clip		1g	3 x 1g			
- Top plate		53g	1 x 53g			
- Strain relief		8g	1 x 8g			
- Bearing cage		19g	1 x 19g			
- Base		143g	1 x 143g			
Standard components					**Manufacturing process**	**Machine used**
Anodized screws	Stainless steel		4	€0.90 per piece	Screwing	Screw driver
Ball bearing	Stainless steel	9.1 mm	8	€1.65 per 100 pieces	Pushing	Hand tools
M5x30 Bolts	Stainless steel		6	€0.90 per piece	Sinking bolts	Drill
Epoxy resin	Epoxy resin			€0.17 per 1 gram	Glueing	Mixing cups & scoopula
USB ports	Brass (copper and zinc alloy) plated with nickel		4	€5 per piece	Soldering	Soldering iron
USB C connector			1	€3 per piece		
Wires	Copper	185 mm	4	€0.05 per piece		

3. Manufacturing plan:

Process	Equipment	Time	Quality control	Risk assessment
Designing the prototype using CAD				
Develop the prototype as CAD model using Fusion 360 software	Computer	10h	Ensure dimensions are correct and component counts are correct.	Sitting mat cause neck and back issues
Manufacturing and finishing the prototype				
Manufacture 3D CAD files using FDM 3D Printer (Process 1)	FDM 3D Printer	28h 15 min	Monitor printing process to check for misalignments midway through manufacture	Heated print bed / nozzle / motors could cause burns Toxic fumes can be inhaled Ensure print bed, nozzle, motors have cooled before touching printer Place printer in enclosed space to minimise hazardous contact
1. Choose certain number of foot-bases and arc-segments necessary for your workspace				
2. Save completed CAD design as either .obj or .stl file				
3. Drag file into software “Ultimaker Cura” 3D printer bed				
4. Orientate onscreen model into correct position and add supporting materials				
5. Set layer height and percent infill (illustrated in process 1)				
6. “Slice” the model and save onto a USB				
7. Load PLA filament. Insert USB > Select file > Print				
8. Once complete, remove model from printer and remove support materials				
Finish component	Hand tools, sandpaper		Wear gloves when working with sharp tools. Check for smooth edges/gaps with a vernier calliper.	Sharp tools can easily cause cuts
Assembling of the prototype				
Assemble the all arc-segments components (Process 2)	Epoxy resin	10min/item	Ensure arc-segment components parts are safely stuck together Wear gloves while operating with epoxy resin	Use gloves to avoid epoxy resin sticking Be careful with sharp edges
Join all arc-segments components to construct the desired shape	Epoxy resin	8min/arc-segment		
1. Apply glue to the left and right joint of the first arc-segment				
2. Joint arc-segment by matching together their joints of sidewalls and bottom LED holders				
3. Remove any remaining glue from outside (with acetone) until the construction is smooth				
4. Repeat the previous steps for each arc-segment				
Assemble all foot-base components	Epoxy resin, ball bearings, anodized	16min/foot		

	screws, M5x30 bolts, screw driver, M5 thread tap			
1. Drill out the built-in support of the three holes for the M5 bolts with a 5.5mm drill bit				
2. Thread the three holes all the way through with the M5 thread tap				
3. Insert 9.1mm ball bearings into the bearing-cage by applying some force				
4. Repeat the previous steps for each foot-base				
Glue the LED strip to bottom part of the arc-like structure (made of arc-segments)	Epoxy resin, LED strip, wires	2min/arc-segment	Check all LED strips are securely stuck with the arc-segments without any gaps	
1. Apply epoxy resin to LED strips' backs to adhere them to the curved segments				
2. Pass LED strip wires through top plate. Assemble top plate with circular groove pointing downward.				
3. Apply epoxy resin to the bottom of the curved arc-segment				
4. Stick the LED strip wires to the strain-relief				
Integrate electronics into foot-bases	USB ports, USB C connector, soldier iron, soldering stand, wires, epoxy resin	15-50 min/foot		Burnings might occur from soldier Check all cables are in good condition
1. Insert the wires from the power supply through the middle channel of the strain relief.				
2. Solder a resistor and a capacitor in front of LED strip				
3. Integrate three USB ports into the three pre-designed holes				
4. Solder the wires to the USB ports				
5. Push USB C connector into the fourth pre-designed remaining hole				
6. Solder the wires to the USB C connector making it the main power supply for the lamp				
7. Insert all the wires through the bearing cage				
8. Guide the wires through the hole in the rear leg of the base				
Finalise assembly by joining all major components	Epoxy resin, M5 thread tap, M5x30 bolts and washers	20min		Burning might occur from epoxy resin
1. Stick it all together, ensuring LED strip isn’t pulling anything when spinning				
2. Insert an M5x30 bolt with washer. Don't over-tighten the bolt. The top must freely rotate.				
3. Repeat previous step for the other two M5 bolts/washers				
4. Connect LED strips to a power source				
5. Fasten the anodized screws to the workspace surface				

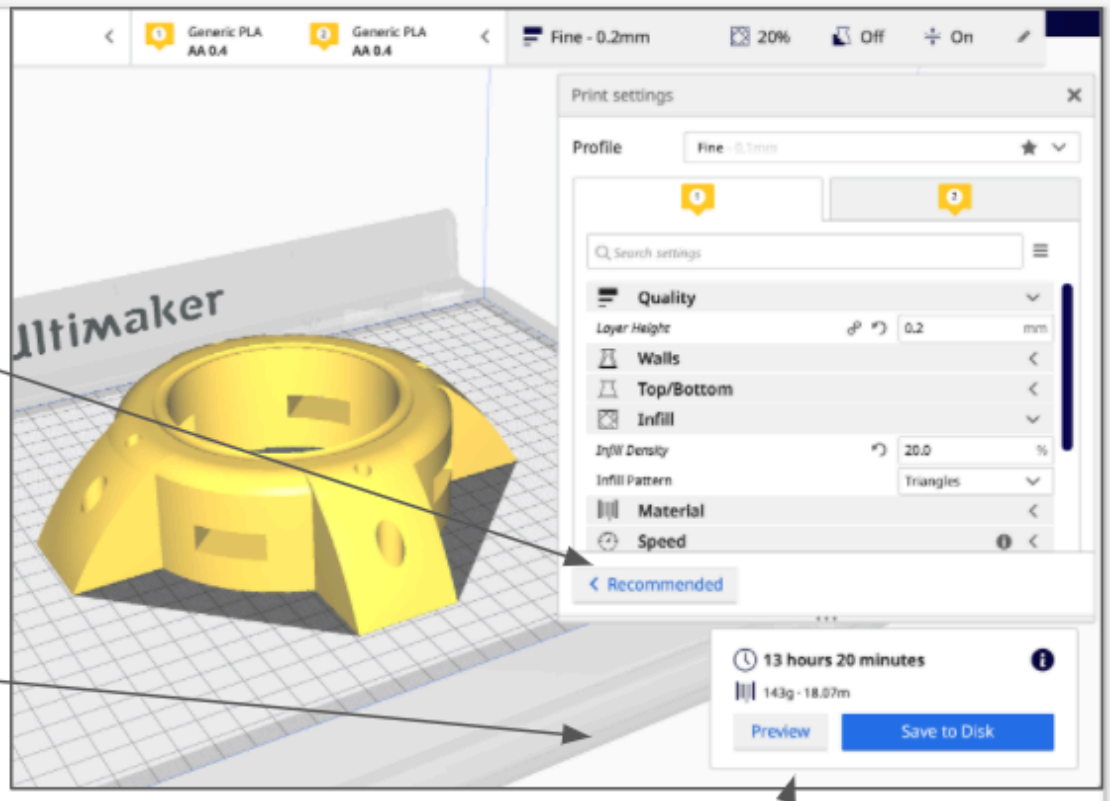
Process 1: Manufacturing (completion of all 3D prints)

Component Name	Grams/print	Time	Layer height	Infill (%)
Foot base				
Base	143g	13h 20 min	0.2	20
Bearing cage	19g	2h 22 min	0.2	40
Strain relief	8g	55 min	0.2	20
Top plate	53g	5h 57 min	0.2	40
Clip	3g (3 per print)	9 min	0.2	40
Arc Segment				
Side wall right	16g	1h 43 min	0.3	20
Side wall left			0.3	20
Top wall A	4g	32 min	0.3	20
Top wall B		29 min	0.3	20
Bottom LED holder A	10g	1h 23 min	0.3	20
Bottom LED holder B		1h 25 min	0.3	20

Higher layer height & surface finish > lower speed of print

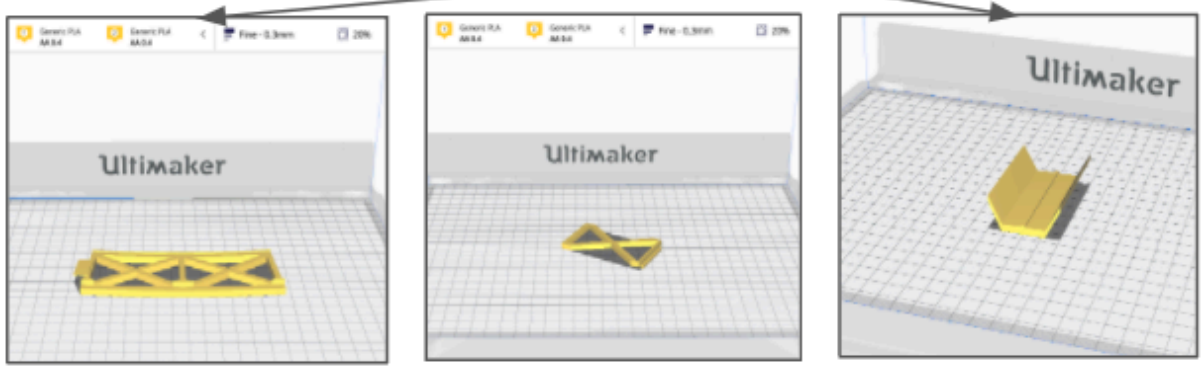
For most components, the layer height was reduced to 0.2mm. This enables for quicker printing without sacrificing surface quality.

Most components have a 20% infill, which provides for good endurance.

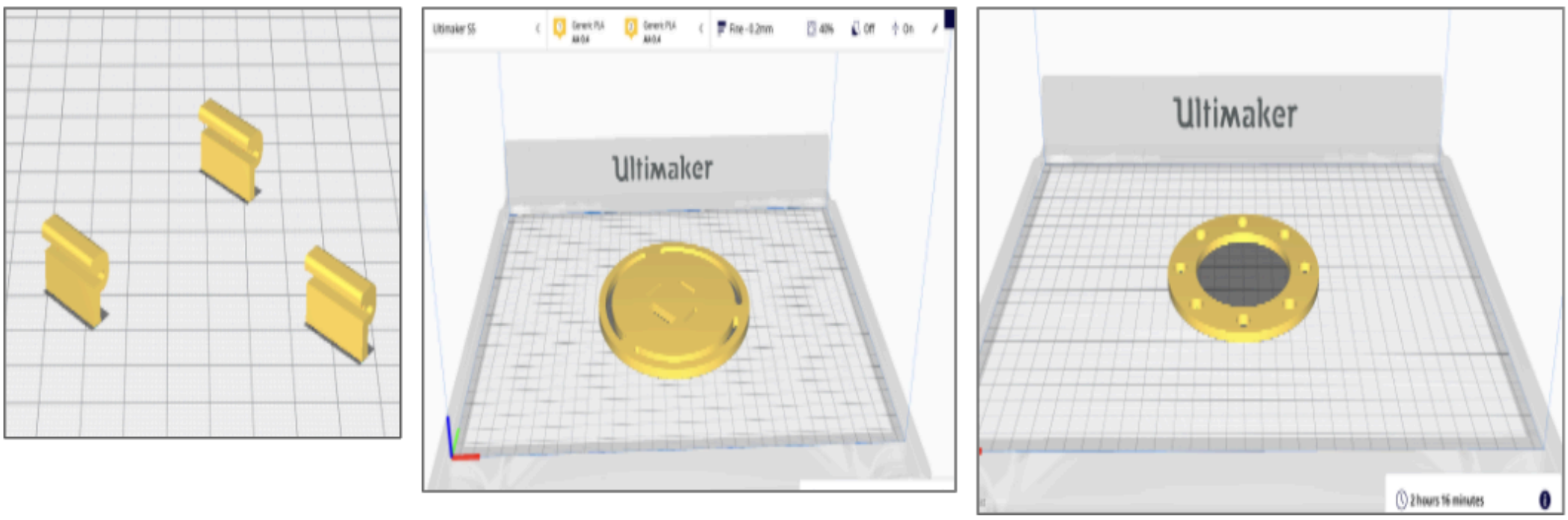


Print time & component weight

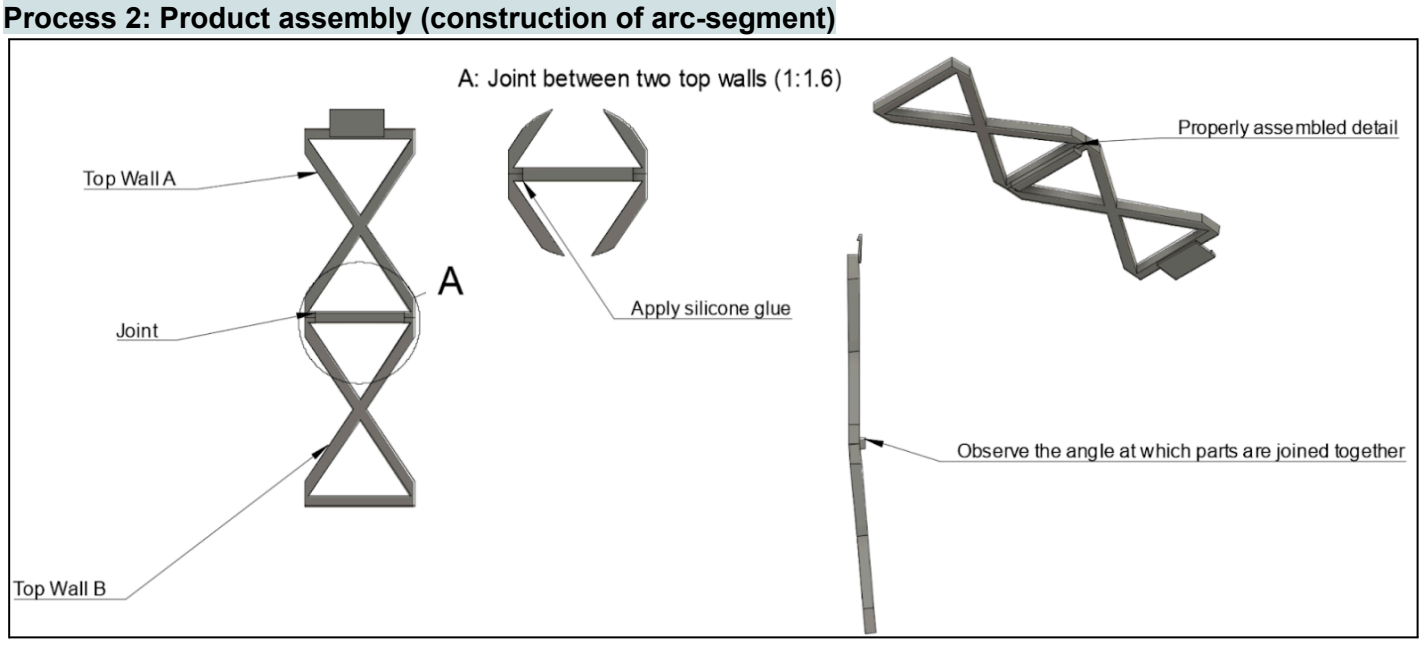
For these components, a higher layer height (0.3mm) is used to improve aesthetic characteristics (because they are exposed to the user)

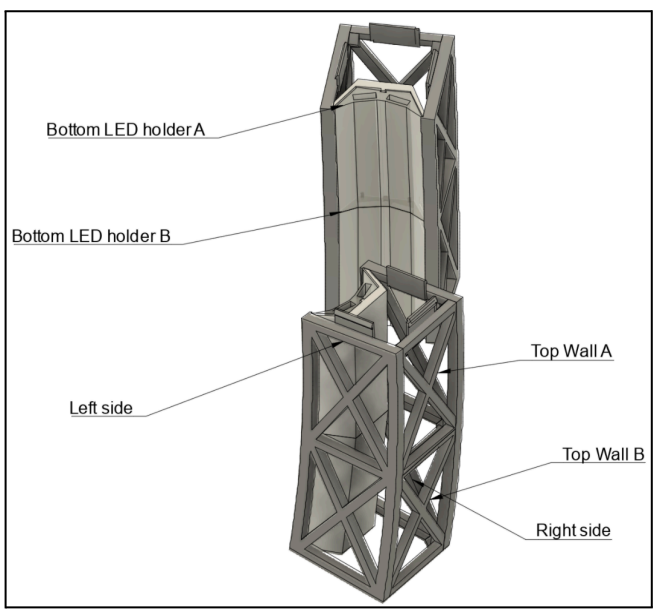


Higher % infill for these components, which rub against each other (rotating base)



Process 2: Product assembly (construction of arc-segment)





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