EXPLORING SHADOWS:
AN INTERACTION BETWEEN LIGHT AND PAPER

VISUAL COMMUNICATION PROJECT III

BY

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GUIDE

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Exploring Shadows

An interaction between Light and Paper

Approval Sheet

The Visual Communication Project 3, entitled ***"Exploring Shadows: An interaction between Light and Paper"*** by *Kalagouda Patil, 156250010*, is approved in partial fulfilment of the requirement of the Master of Design in Visual Communication.

Project Guide 

Chair Person 

Internal Examiner 

External Examiner 

Declaration

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any idea/data/fact/source in my submission. I understand that the violation of the above will be cause for disciplinary action by the institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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My sinciere thanks to **Prof. Mandar Rane** for his guidance and encouragement.

I would like to thank **Classic Enterprises** and its staff who were patient and helpful whenever I visited them for laser cutting service.

I am grateful to all my faculty and friends at Indian Institute of Technology Bombay for their support in the thought process for the accomplishment of project.

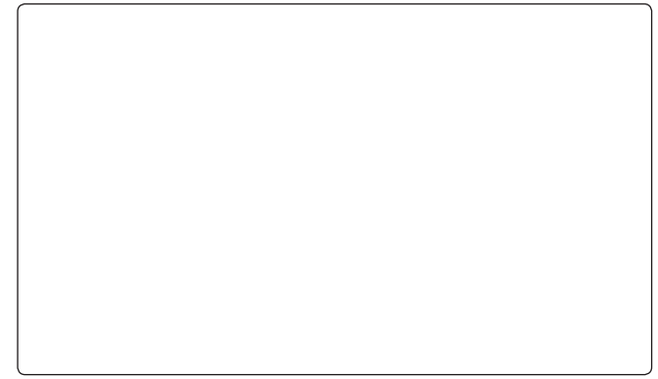
Abstract

This projects explores the possibilities of interaction between a light source and a subject which projects the impression of a subject on a screen called The Shadow. Considering Light source and subject as major variable factors, their behaviour of interaction is altered by changing properties and hence the resulting phenomena is observed. Domestic lights are used as medium for the light source and paper is used as the material for the subject. Lamp is chosen as a medium to explore these variables, as it is a perfect model which leads this exploration towards a tangible product.

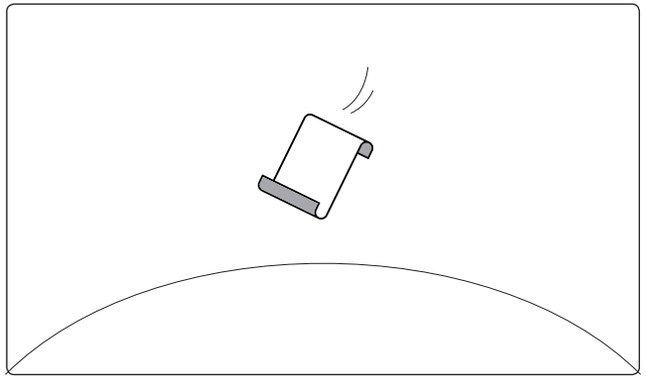
Contents

The Beginning

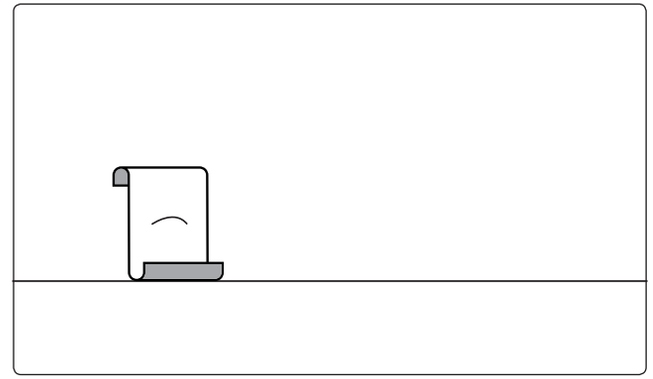
Once upon a time, there was...



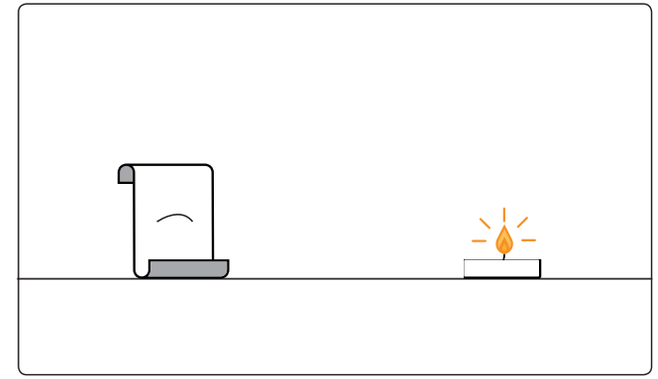
...nothing



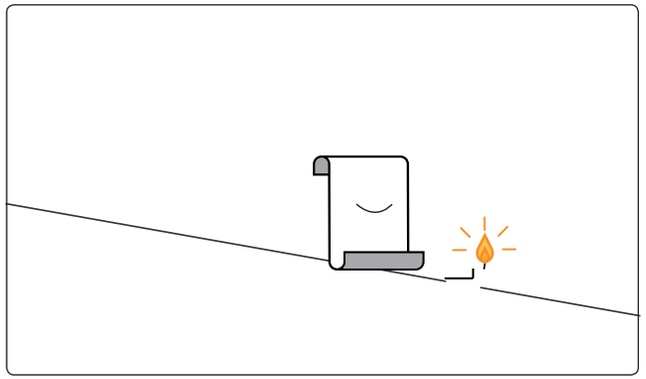
then, ***paper*** came into existence...



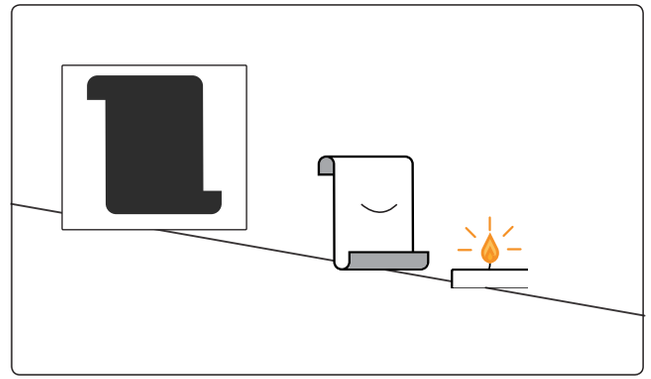
...who was lonely and bored.



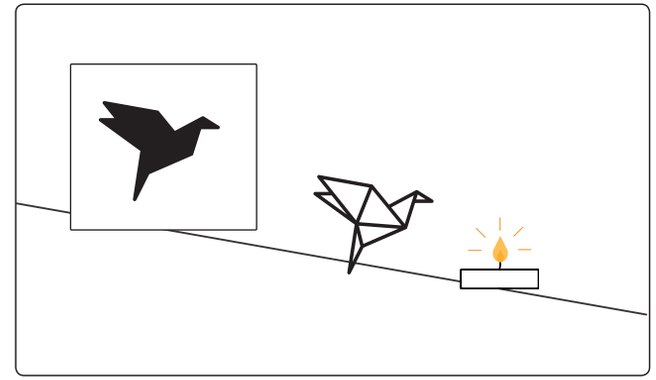
One fine day, he met a ***burning candle***.



When they interacted...



...***shadow*** happened on a plane called ***screen***.



As they changed the behaviour of their interaction, the ***shadow*** changed.

The story revolves around four elements
1. Burning Candle (Light Source)
2. Paper (Subject)
3. Screen
4. Shadow

'Exploring Shadows' is a project which explores the interactions between these four elements.

Elements

Light Source

Light source is an illuminating element which generates light energy either by combustion, electricity or other forms of energy.

Object

The role of object is to block the ray on its path, which results to cast shadow on a surface.

'Paper' is used as an object material in this project. Paper is a thin material produced by pressing together moist fibres of cellulose pulp derived from wood, rags or grasses, and drying them into flexible sheets. It is a versatile material with many uses, including writing, printing, packaging, cleaning, and a number of industrial and construction processes.

Some of key reasons to choose paper over other sheet materials for object
such as

- Ease of availability
- Cheap and economical
- Easy to mould the material
- Variety of options to choose (colours, texture, GSM, opacity, etc.)
- Hight structural strength

Due to its versatile nature, various forms and structures were explored in later stages of exploration.

Screen

Screen is a surface on which the light rays (from the source) and the shadow (resulting due to obstruction of light by the object) is projected.

Screen is consciously placed in the setup or is manifested based on the chosen environment. For example wall, floor, piece of paper/cloth, non-planar surfaces to distort the shadow.

Shadow

Shadow is the resulting silhouette like image resulting due to the obstruction of light by the object.

Mary had a little Lamp

The first lamp - invented around 70,000 BC - was a dish of stone containing moss dipped in vegetable or animal oil.

Wicks were later added to control the rate of burning, a primitive way to control the service lifetime of the light source. Torches too - wooden sticks dipped in oil or covered with cloth dipped in a similar fuel were used as 'handy' light sources.

Around the 7th century BC, terracotta oil lamps started to replace hand-held torches. All types of vegetable oil or by product greases and other animal fat oils were used as fuel. A major problem was to obtain a sufficiently liquid fuel to be wicked.

These primitive oil lamps were succeeded by the wax candle. To increase the light output and protect the flame, the lantern - equipped with a primitive reflector protected by a front glass - was invented.

All by all, the efficiency of a candle, oil lamp or lantern remained low. The luminous intensity of a candle as a point source being but a 1 cd.

To boost the efficiency and control the light output of the oil lamp, in the 18th century the central burner was invented, a major improvement. The fuel source was now enclosed in a metal container, and an adjustable metal tube was used to control both the rate of the fuel burning and the intensity of the light.

Incandescent lighting: The principle of the incandescent electric lamp was developed by the American electrician Moses G. Farmer in 1858–59 but his design was not practicable. Sir Joseph Swan in England and Thomas Edison in the United States, working independently, developed lamps of this kind; the lamp patented by Edison in 1879 was the first widely marketed incandescent lamp and was the forerunner of the modern incandescent lamp that utilizes a tungsten filament sealed in a glass envelope that is either evacuated or filled with inert gas.

On the other hand, while discharge lamps began with arc lamps and the German inventor Geissler devised the Geissler tube in 1859, these lamps were overshadowed by the remarkable progress being made with incandescent lamps and went largely unnoticed. However, in 1893 the Moore lamp was invented and the development of discharge lamps began to take a more promising course. Neon lights where invented in 1914 and finally in 1938 the American inventor Inman invented the

fluorescent discharge lamp.

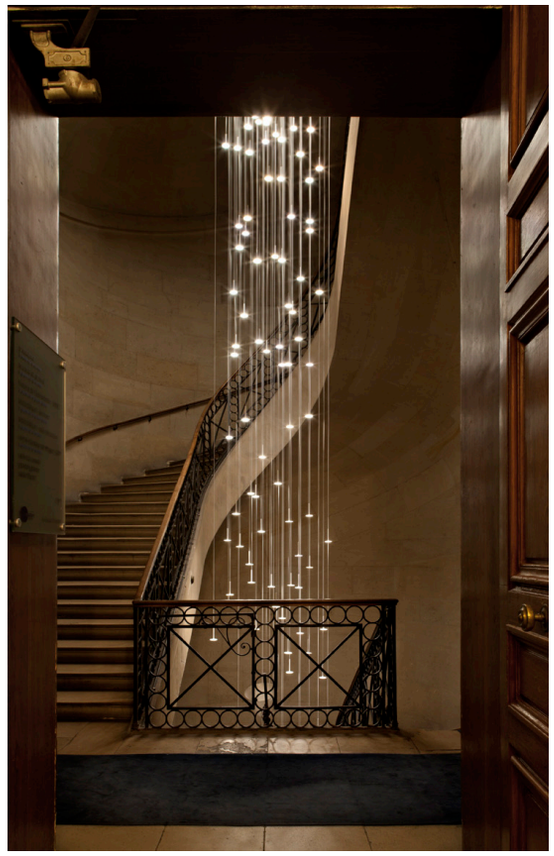
Electric lamps and light bulbs underwent various enhancements as the result of a variety of successes and failures and have progressed in tandem with improvements in human lifestyles. Today, lighting technology has advanced to the point that electric lights have become an essential part of our daily lives. Every day incandescent, fluorescent, halogen and HID lamps provide light where we live, study, work and play.

Lamp(noun): A device for giving light, either one consisting of an electric bulb together with its holder and shade or cover, or one burning gas or oil and consisting of a wick or mantle and a glass shade.

Types of lamps:

1. Pendant lamp

A pendant light, sometimes called a drop or suspender, is a lone light fixture that hangs from the ceiling usually suspended by a cord, chain, or metal rod.[1]Pendant lights are often used in multiples, hung in a straight line over kitchen counter-tops and dinette sets or sometimes in bathrooms



2. Chandelier

A chandelier /ʃæn.dəlˈɪər/ is a decorative light fixture mounted on ceilings or walls.
[1] Chandeliers are often ornate, and normally use incandescent light bulbs, though some modern designs also use fluorescent lamps and recently LEDs.

Classic chandeliers have arrays of hanging crystal prisms to illuminate a room with refracted light, while contemporary chandeliers assumes a more minimalist design that does not contain prisms and illuminates a room with direct light from the lamps, sometimes also equipped with translucent glass covering each lamp. Modern chandeliers has a more modernized design that uses LEDs, and combines the elements of both classic and contemporary designs; some also equipped with refractive crystal prisms or small mirrors

Chandeliers are distinct from pendant lights, as it usually consist of multiple lamps and hangs in a branched frame, whereas pendant lights hangs from a single cord and only contain one or two lamps without any decorative elements. Due to their size, they are often installed in hallways, living rooms, lounges, and dining rooms. However, smaller chandeliers are also available, allowing them to be installed in smaller spaces such as bedrooms.

Chandeliers were invented during the medieval era and originally used candles. Candles remained in use until the 18th century, and gradually declined with the invention of gas light and electric light.

3. Floor lamps

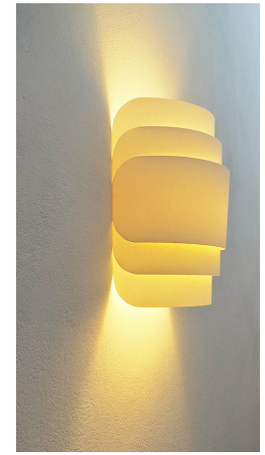
Floor lamps are those that stand on the floor. Larger frames allow these to provide light from a raised source, illuminating whole rooms when placed strategically.









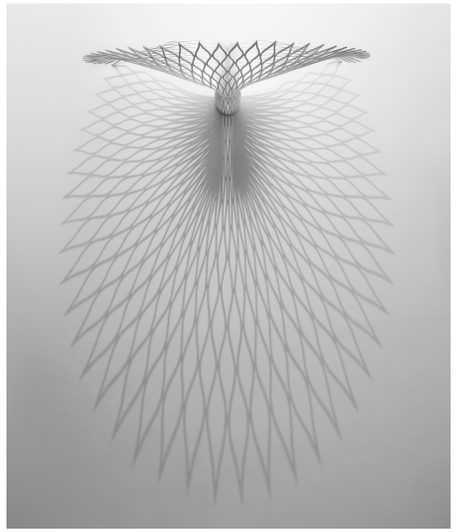
4. Table lamps

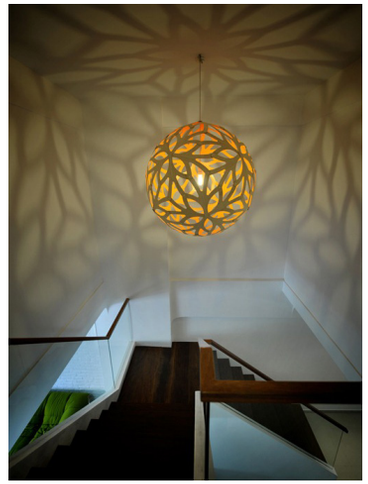
Table lamps are those that sit on the table. These lamps are comparatively dwarf with heavier bases for stability.

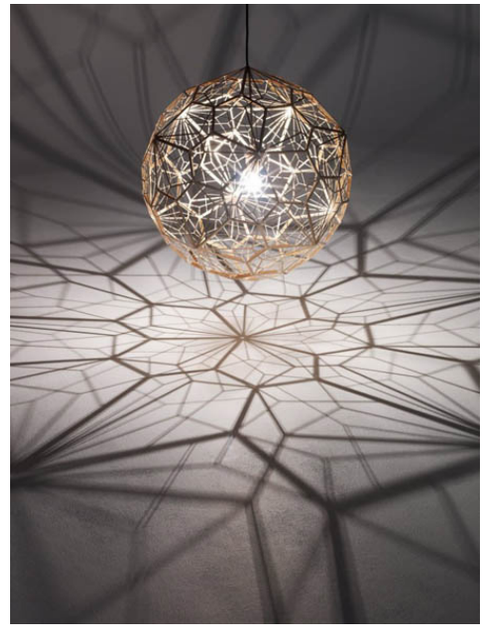
5. Sconce

A sconce is a type of light fixture affixed to a wall in such a way that it uses only the wall for support, and the light is usually directed upwards, but not always. It does not have a base on the ground. For this reason, lighting fixtures will need an electrical box to be installed. A sconce may be a traditional torch, candle or gas light, or a modern electric light source affixed in the same way. Modern fittings are more often called wall lights or similar terms, especially if the light source is wholly covered by glass.

Sconces can be placed on both the interior and exterior walls of buildings. In pre-modern usage, these usually held candles and torches respectively. Historically, candle sconces were often made of silver from the 17th century, with porcelain coming in the 18th.







Existing Designs

Few examples of existing design which uses light and shadow play as the primary element of lamp.

Exploration

The project is explored in 3 stages or parts for the understanding of the behaviour of the system elements - Light, Paper, Screen and Shadow when subjected to various circumstances.

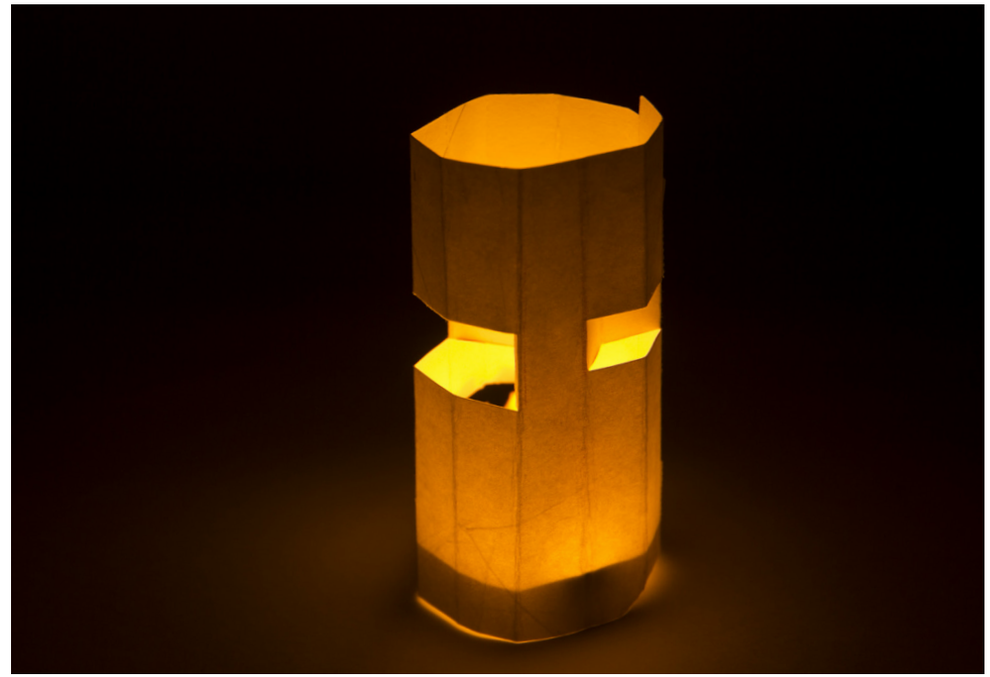
The first part deals with an initial idea and is iterated several times until a finished product is achieved.

The second part explores in a wide manner. The study deals with changing not only parameters of paper but also experimenting with various light sources such as electric bulbs, different sizes and approaches.

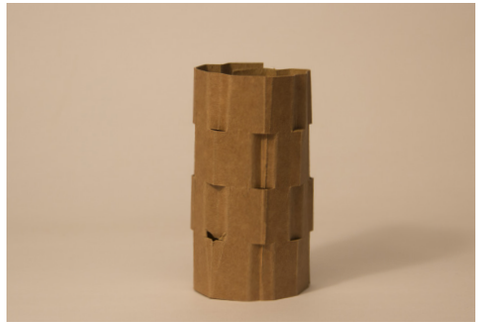
Third part deals with studying the resulting pattern based on changing 3 parameters - Angle, Radial distance and height. Here tea-light candle is used as light source.

Exploration 1

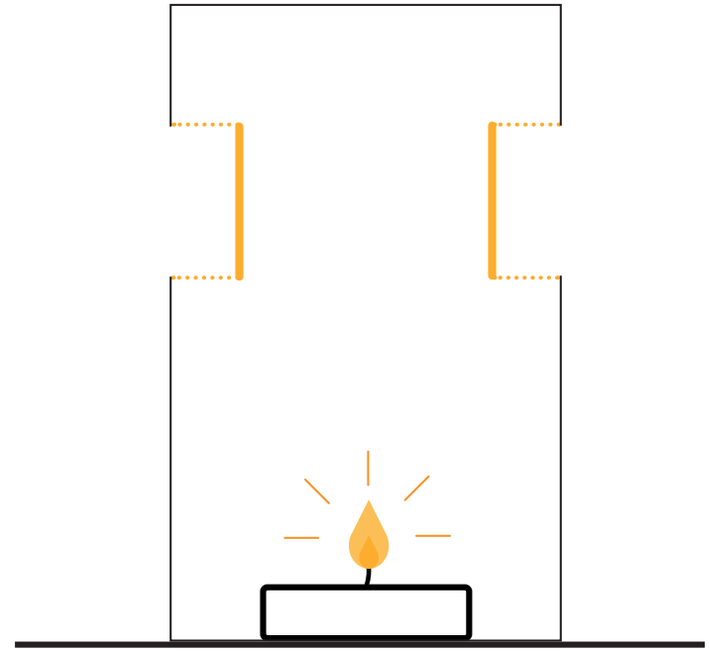
Covering the light source (tea-light candle) with a sheet of paper which provide me a start point where I can make changes and observe the resulting phenomena to take further decisions

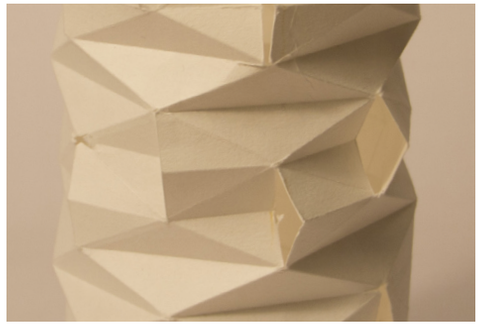


In last iteration, it was observed that light was released parallel to the floor. In this iteration, the paper is cut and shaped such that the light is released normal to the floor in upward direction. The element of paper which are pushed inside are self-lit and acts as screen.

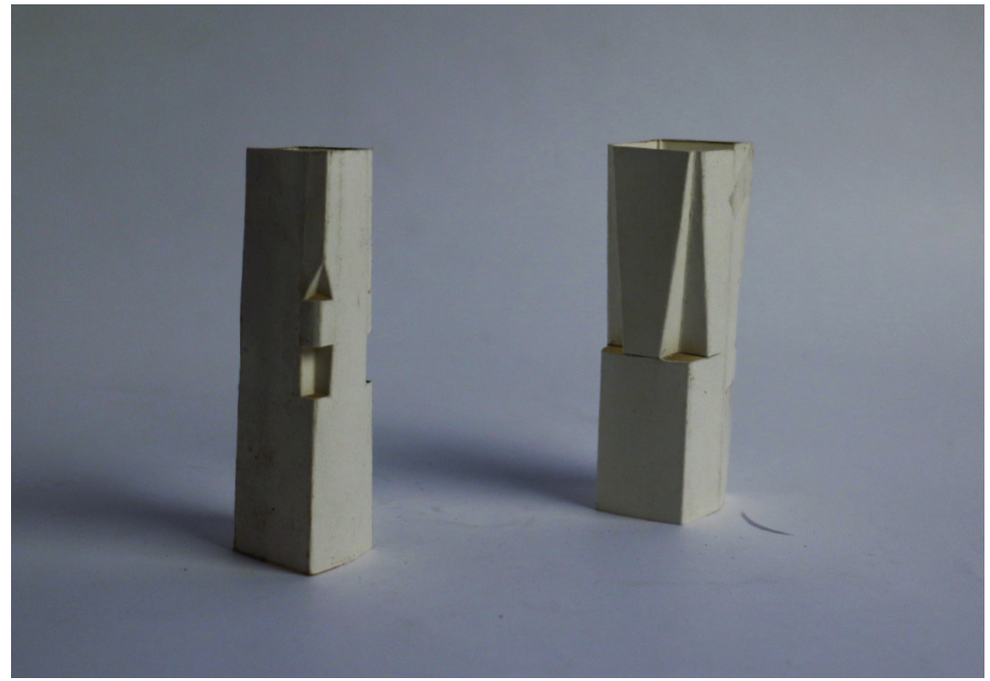


The last iteration is taken further by increasing the number of vertical releasers.

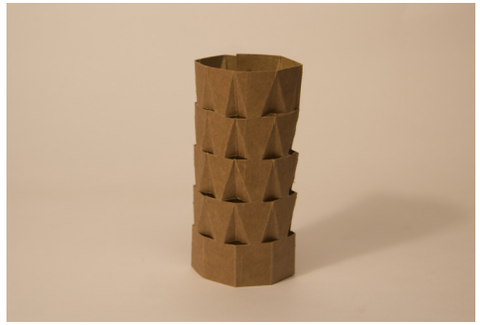


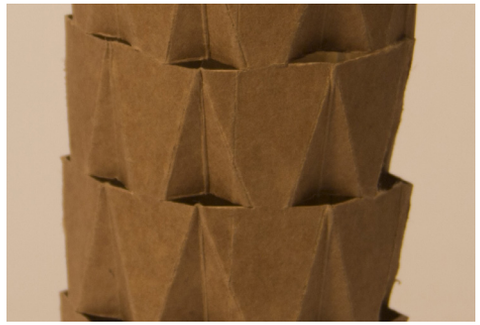


This is inspired by origami structure, which is modified such that the light is released in tangential manner.

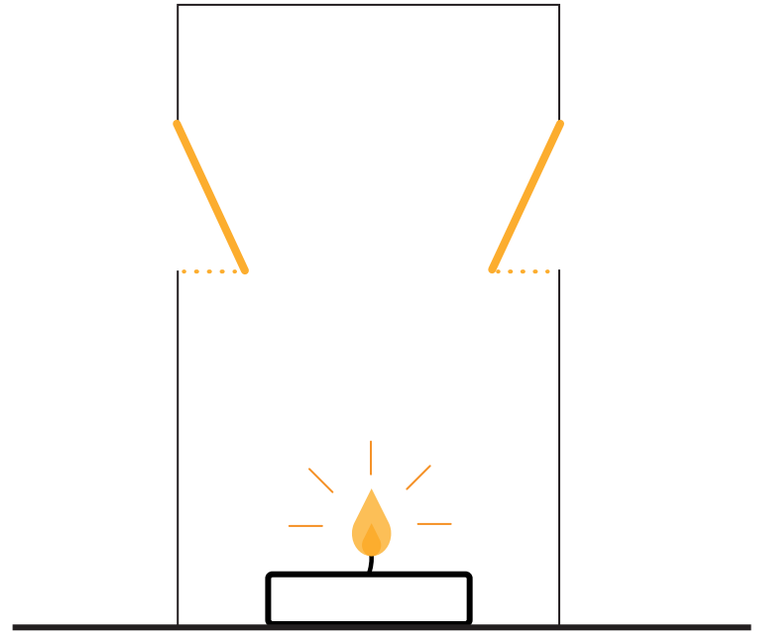


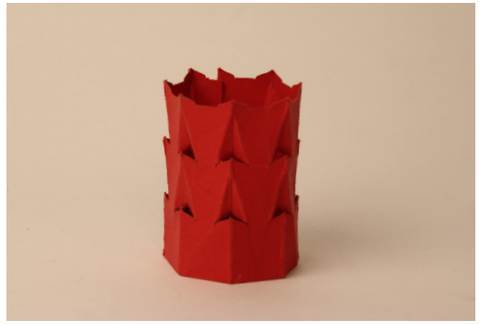
Combing last two iterations, some new shapes were tried.

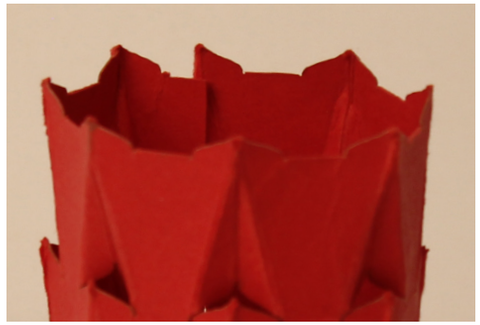




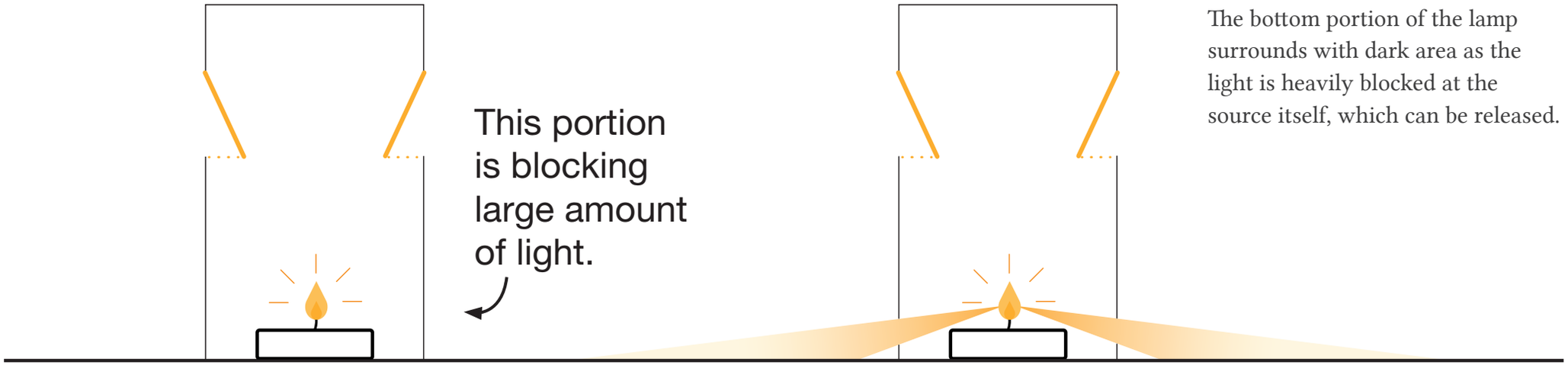
The light is not only released in upward direction but also captured on the small triangular screens.



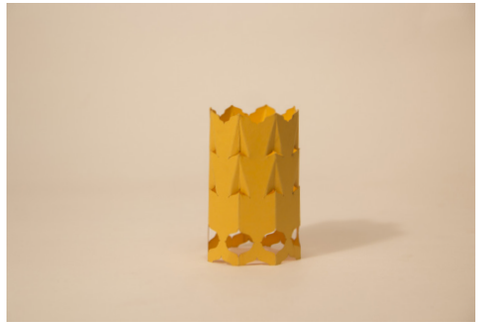


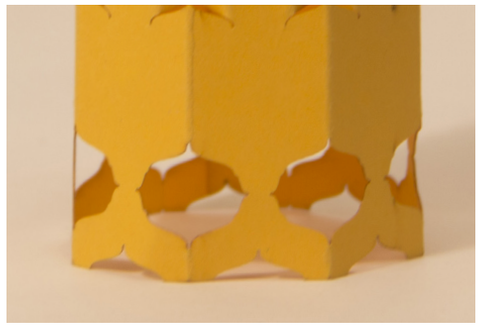


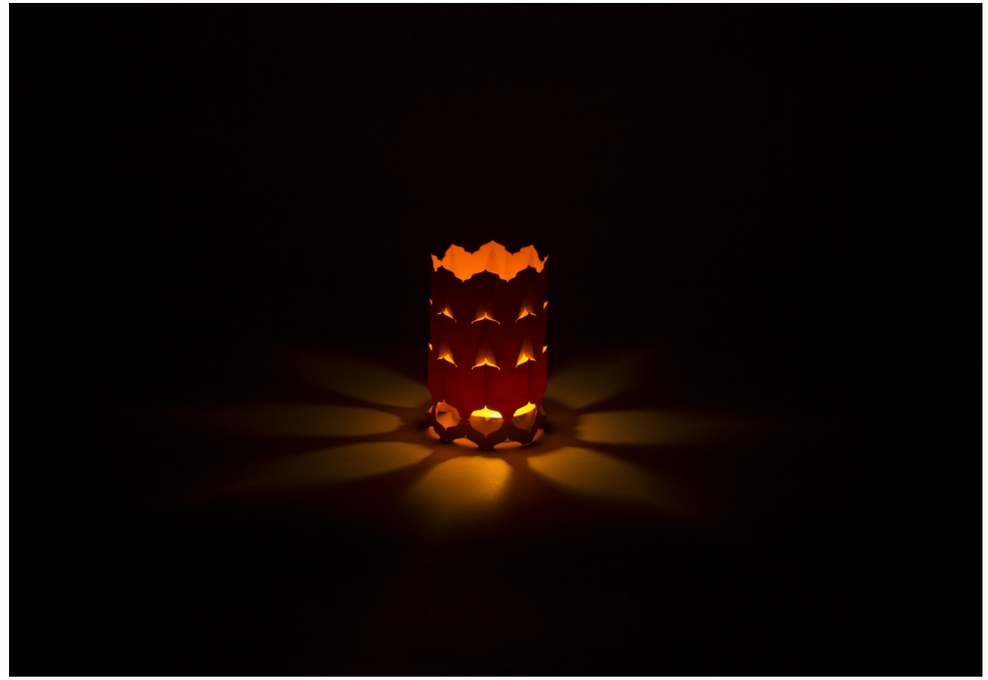
The shape of cutting is developed to increase the elegance of the lamp when it is not lit.



The bottom portion of the lamp surrounds with dark area as the light is heavily blocked at the source itself, which can be released.

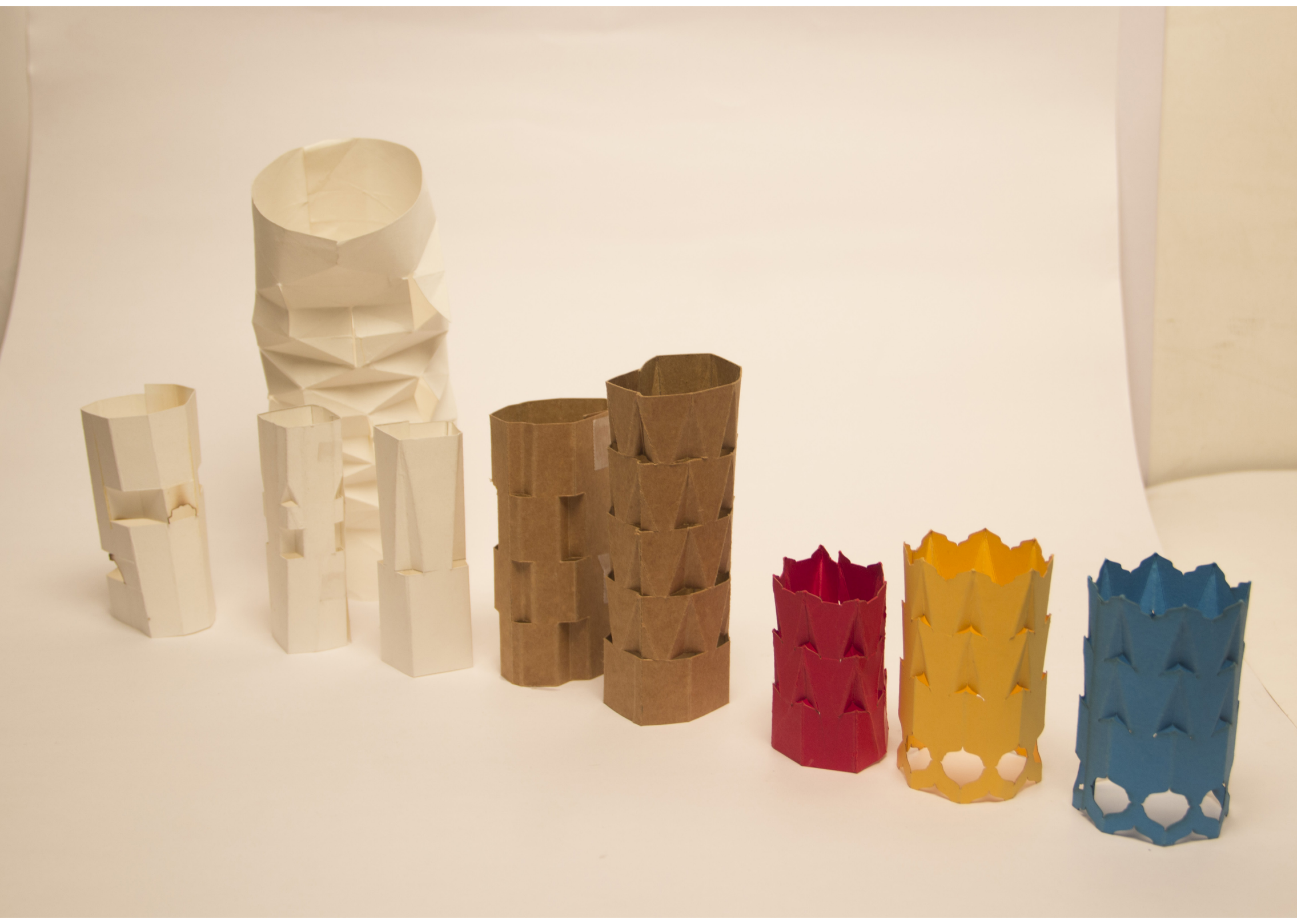


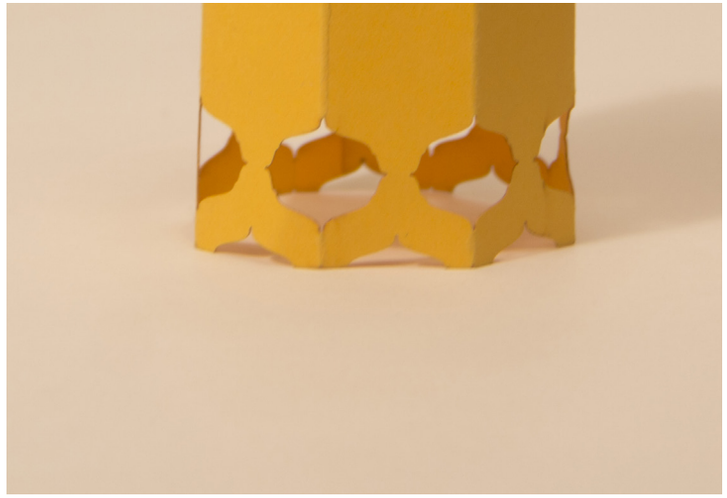




The light released from the bottom cut-out projects on the floor which acts as screen.

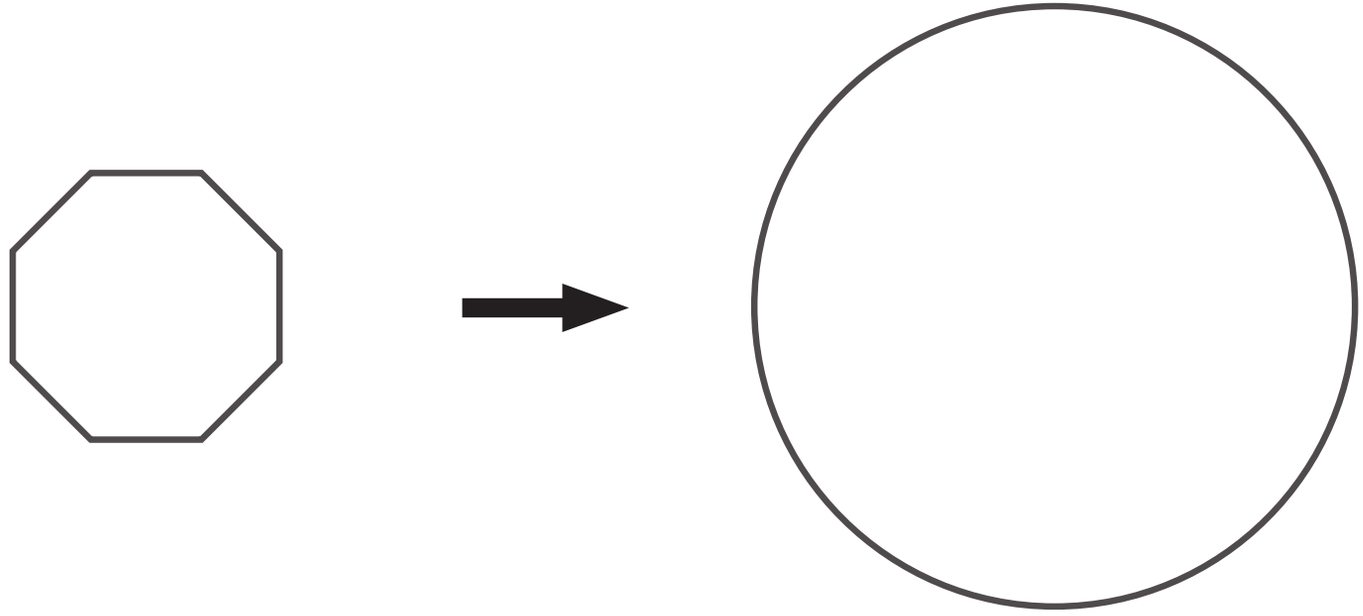
This is one of the finished product achieved. It is named as ‘Stambha’ meaning pillar derived from its physical form.

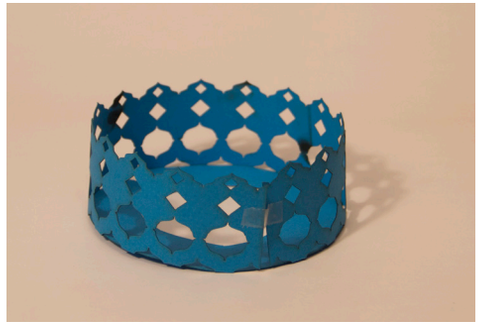


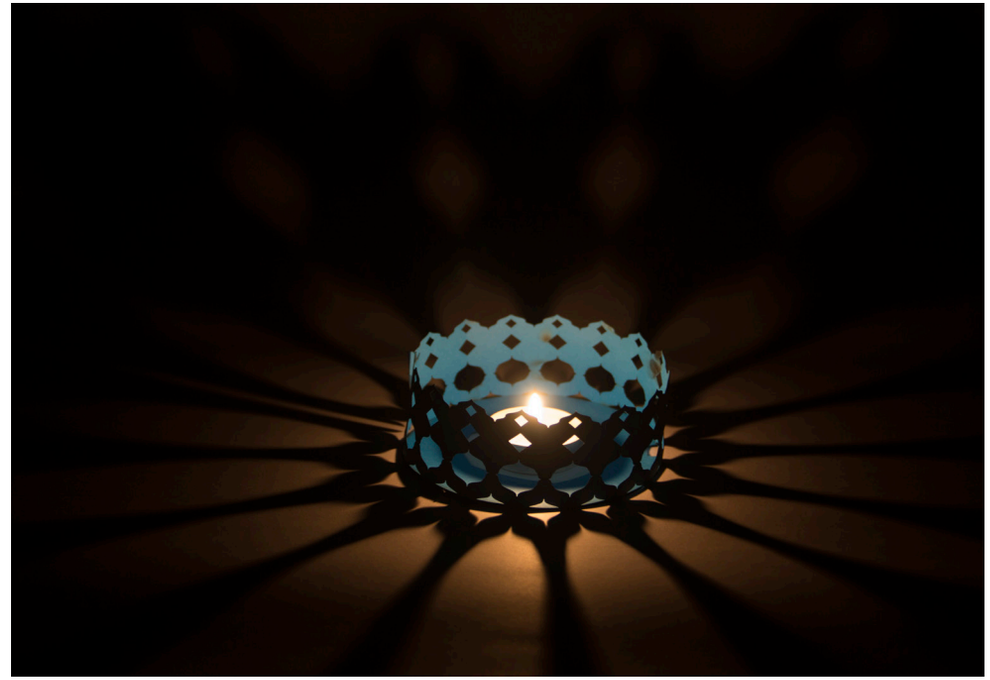


The lamp was iterated further into another form with few modifications

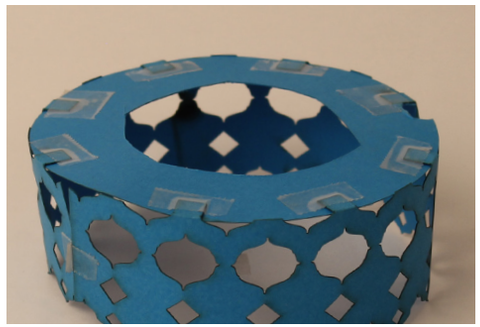
Inspired by the pattern formed on floor, I was motivated to increase the number of petals formed. This was achieved by increasing the diameter of the lamp thereby accommodating more number of cut-outs of same size.

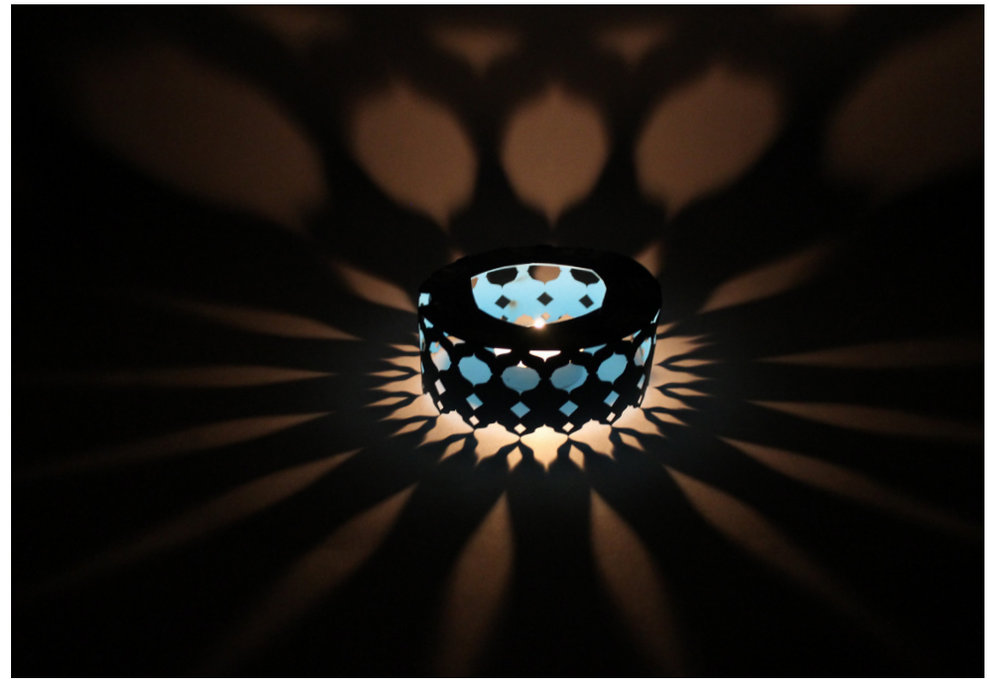




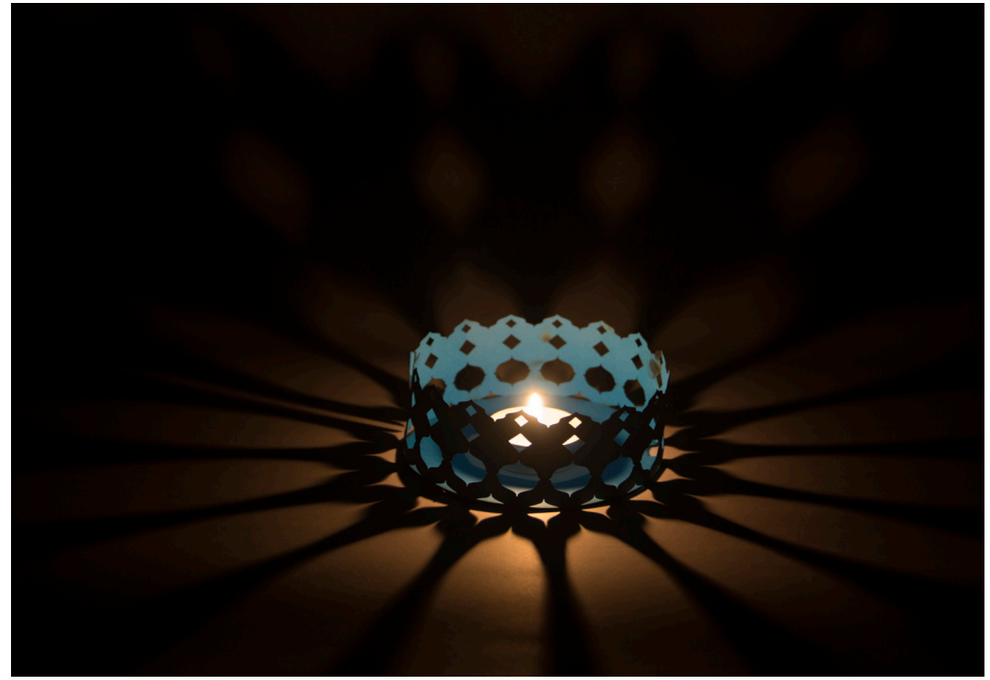


Two cut-outs at the top doesn't play any major role of interacting with light but adds visual continuity to the form. A base was provided to support the cylindrical form structure. The base have a small circular cut-out to place tea-light candle.



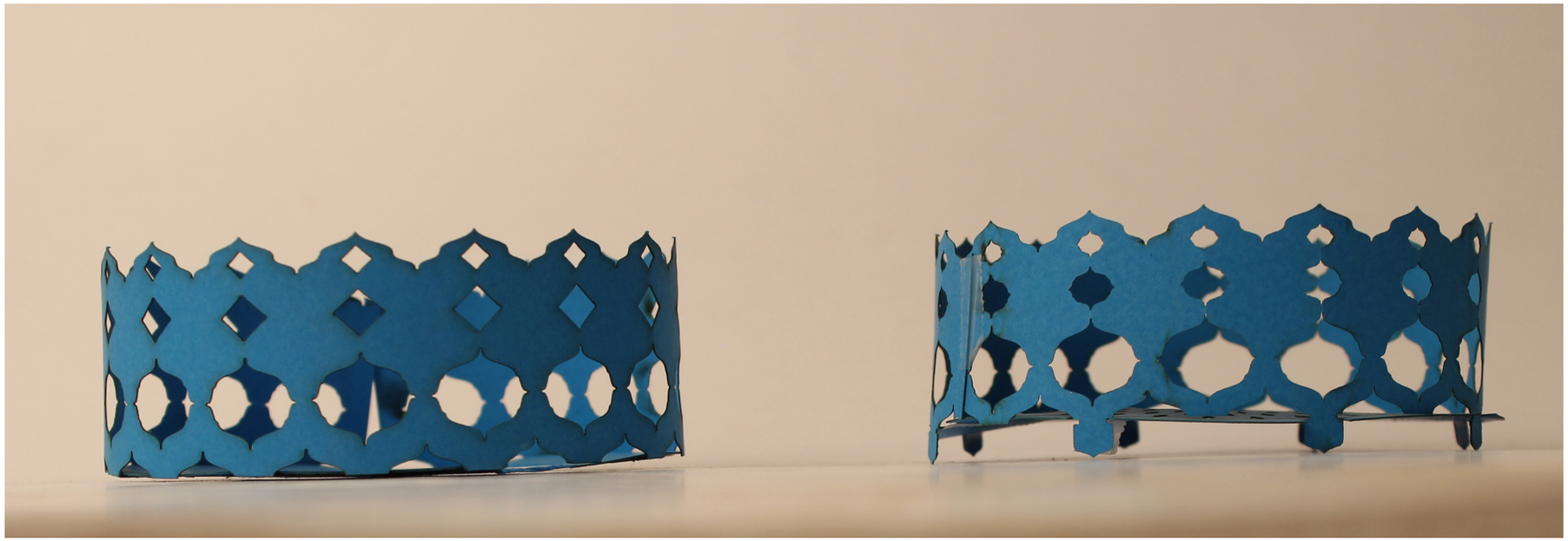


However the lamp is ideated for up-right position, it also works in up-side down position. The form being cut at the border produces a nice pattern which adds a feature of 2-way lamp.

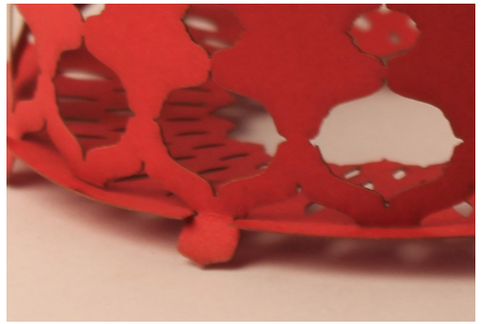


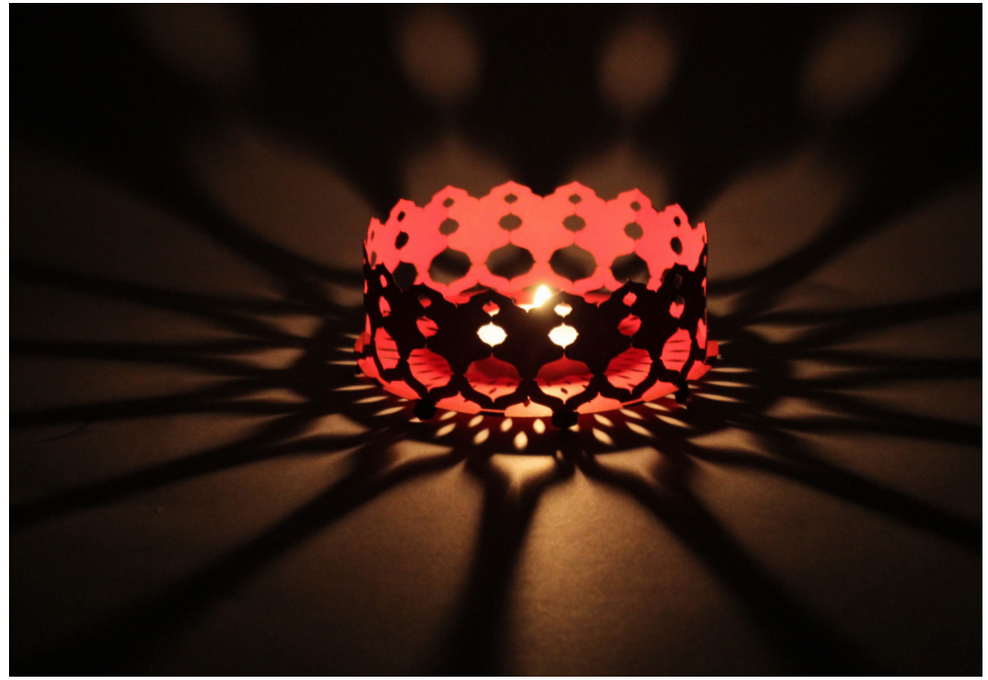
The surface which was intended to be base, blocks ample amount of light when positioned upside down. Hence it is cut-out with smaller elements which doesn't affect the structural strength and still have room for light.

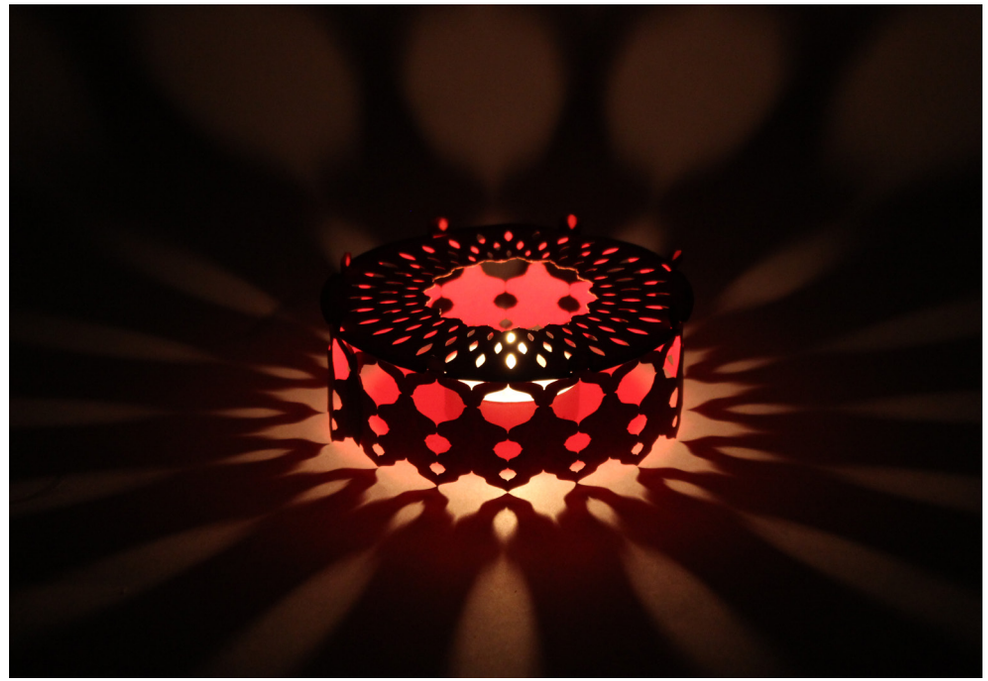
When the light is lit in up-right position, and slightly lifted from the ground, the perforated base adds an extra element of shadow patterns to the existing.



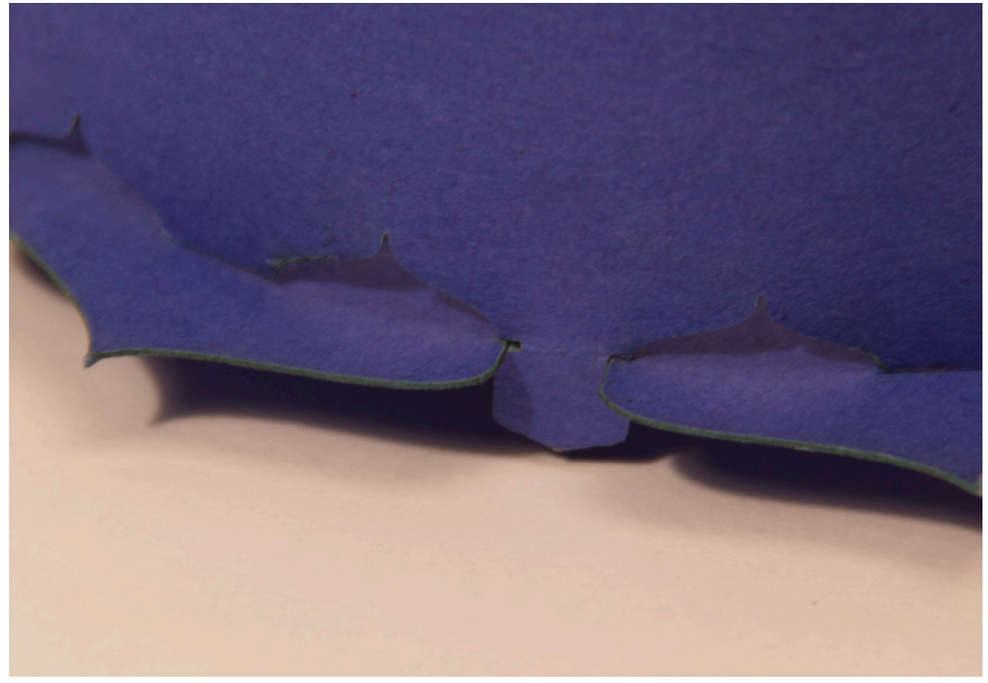
To achieve small rise in height, a small stand is derived from the same paper which in turn helps to interlock the lamp thus minimising the effort of multi-pasting.



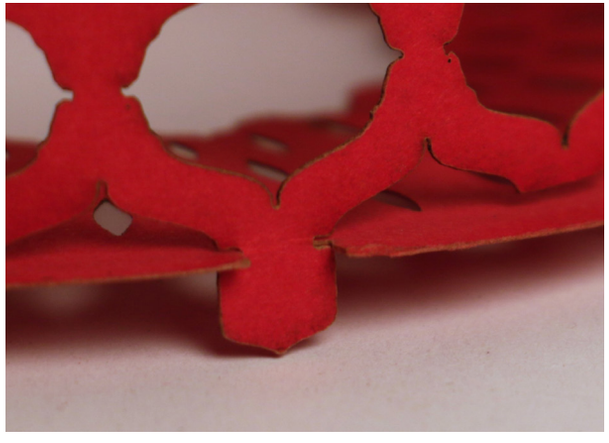


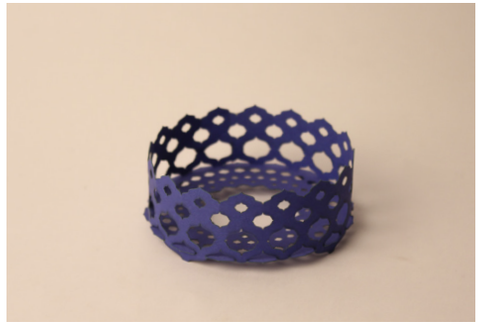


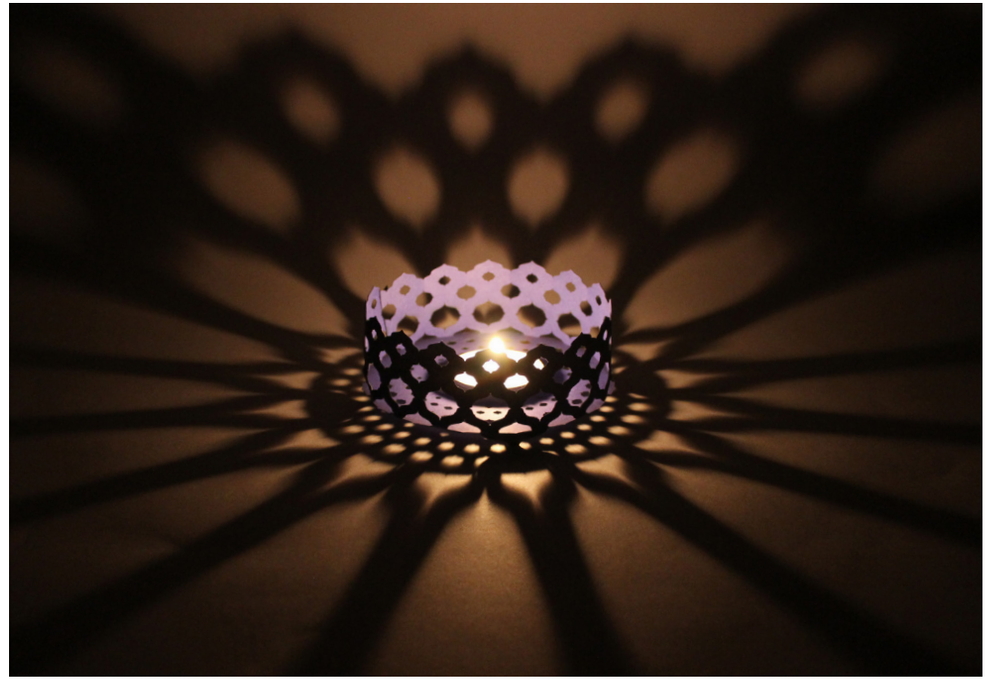
The stand developed works well enough to raise the lamp, but it is structurally weak.

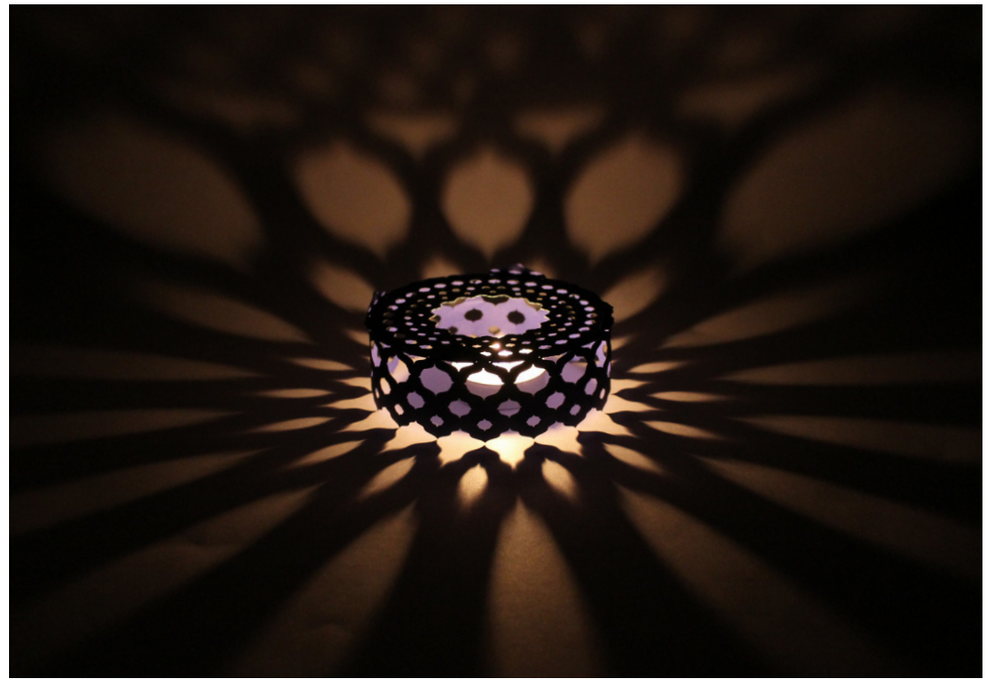


The locking of the structure was developed in further iterations. As the thickness of the paper used (250-300 GSM) is about 0.1mm-0.2mm, the locking slots has to be designed for the same and test until it's perfectly fit and structurally strong.

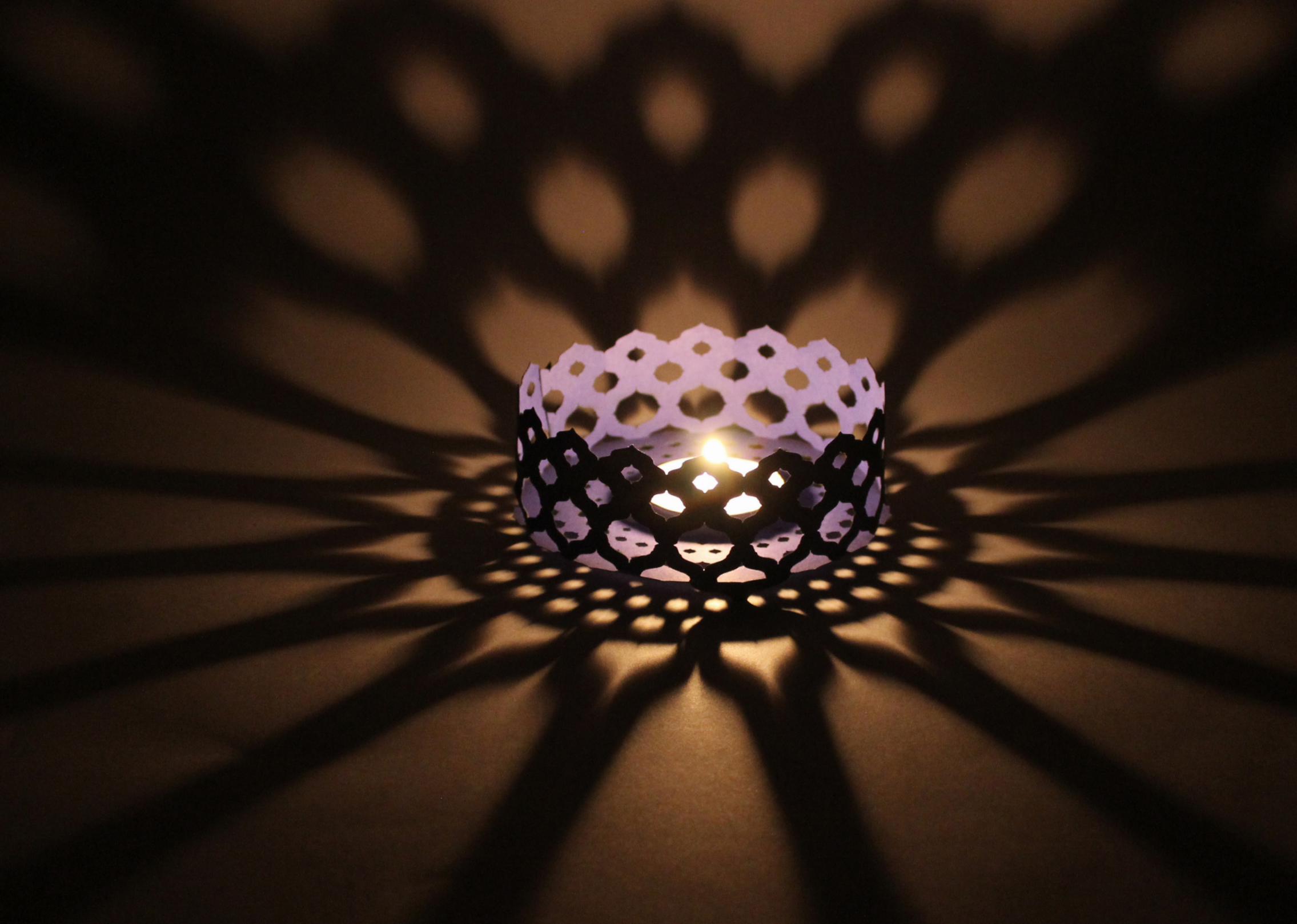


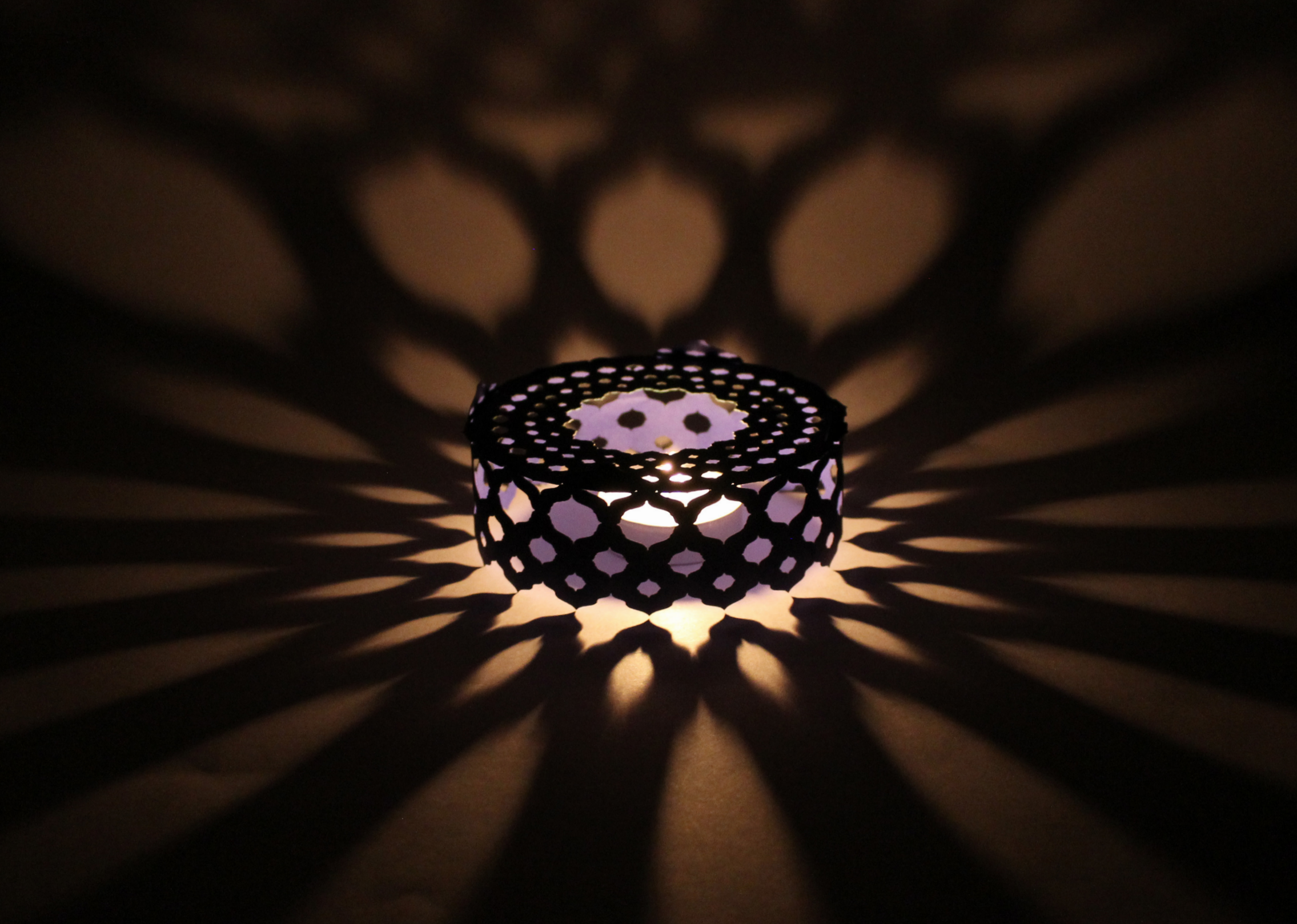






This was second finished product. It was named 'Vistaara', meaning expansion derived from the nature of pattern it creates.



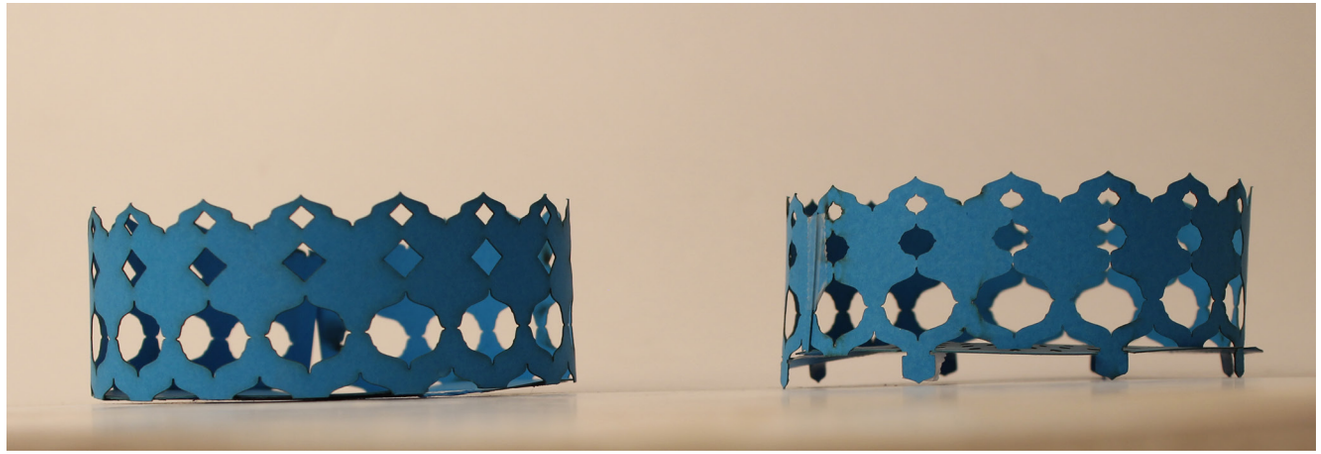


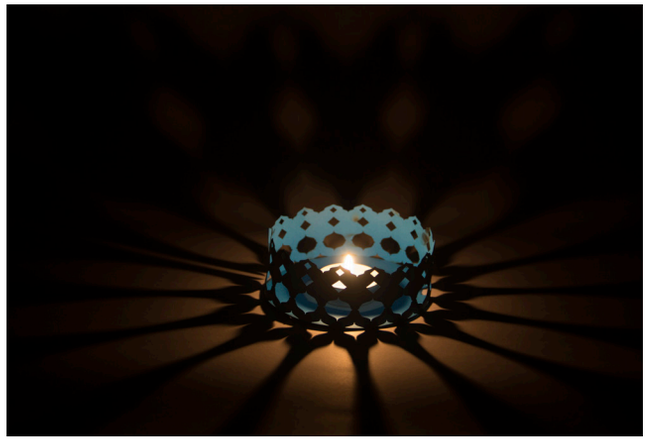
Insights

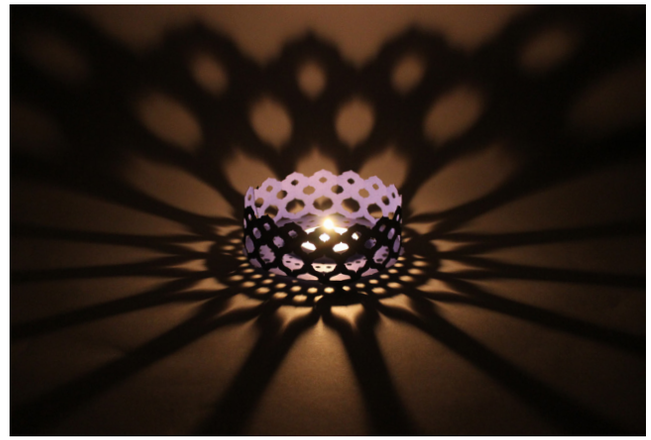
The releasing or blocking or both releasing & blocking of light by modifying the parameters of paper (subject) defines the visual output of light-shadow pattern.

Cut-outs with intricate shapes lose out the details when projected as shadow.

Exploration 2



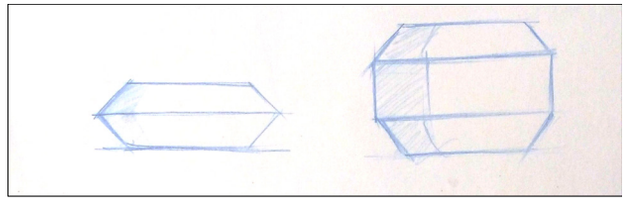


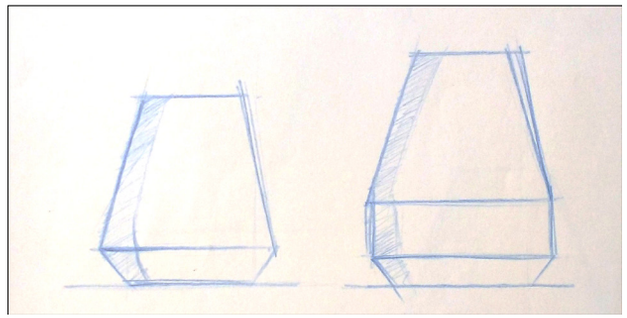


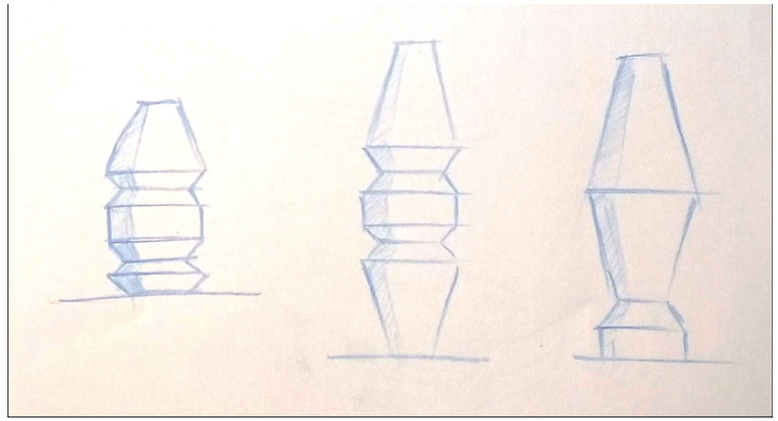
Exploration 2.1

As in the earlier case of ‘Vistaara’ lamp, how the pattern enhanced by perforated base along with the raise in height, it was possible that the shadow might behave differently by changing such similar parameters.

The angle of the base which is 0 degree with respect to floor, was changed to certain angle (<90 degrees).

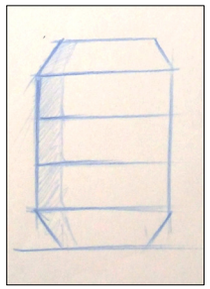


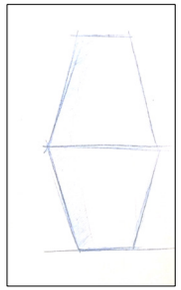


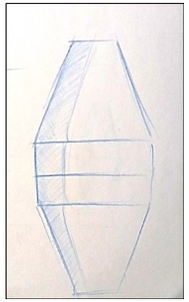


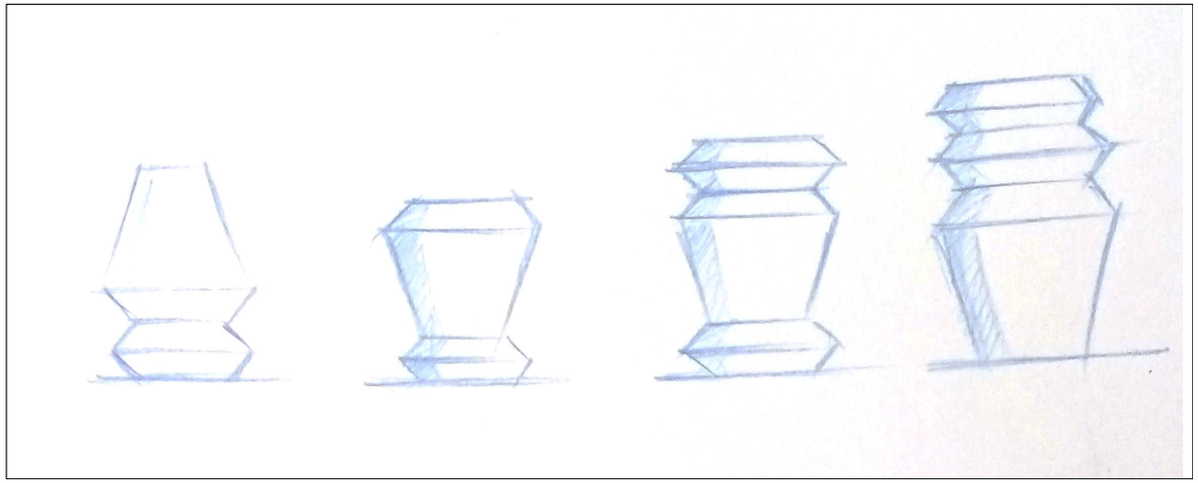
Based on this idea, various forms were ideated.

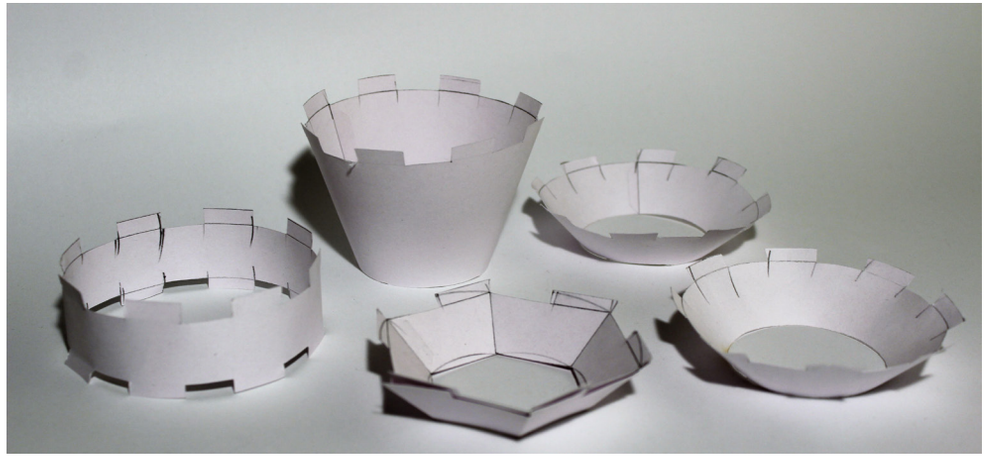
In these forms, only the base acts as main subject which interacts with light source. The upper elements gives physical form to the structure.

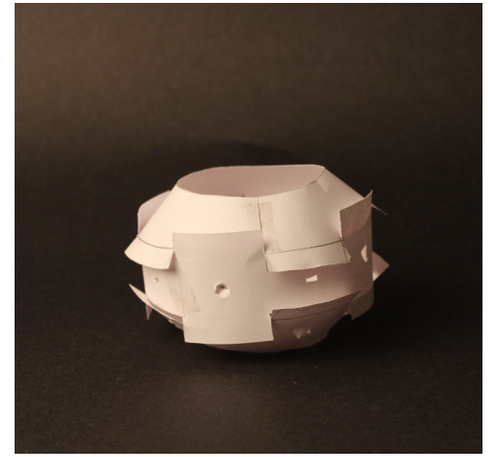


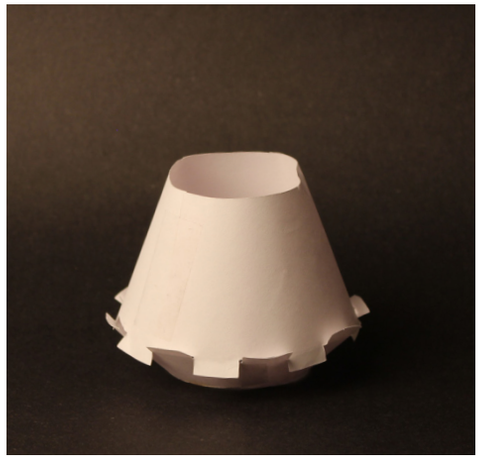


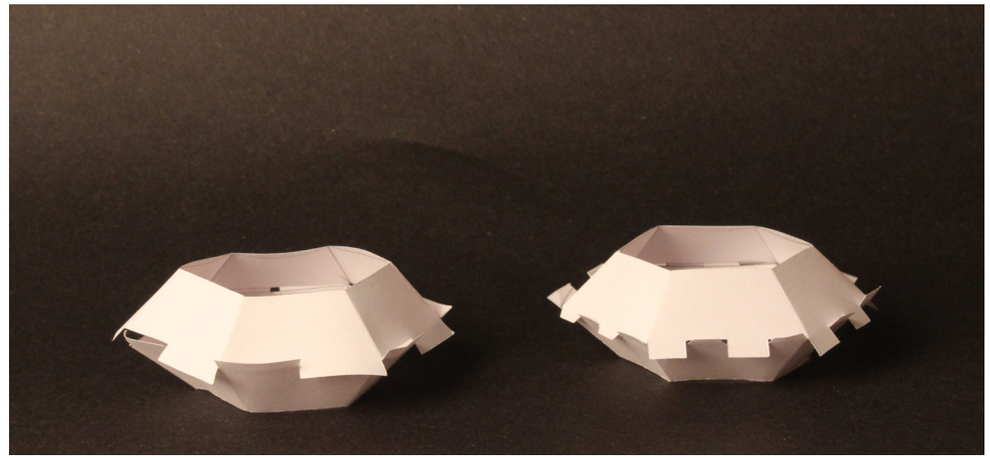












To develop these sketches into 3D prototypes, the development has to be planned in 2D. Each and every element is planned in 2D and then its built into 3D.

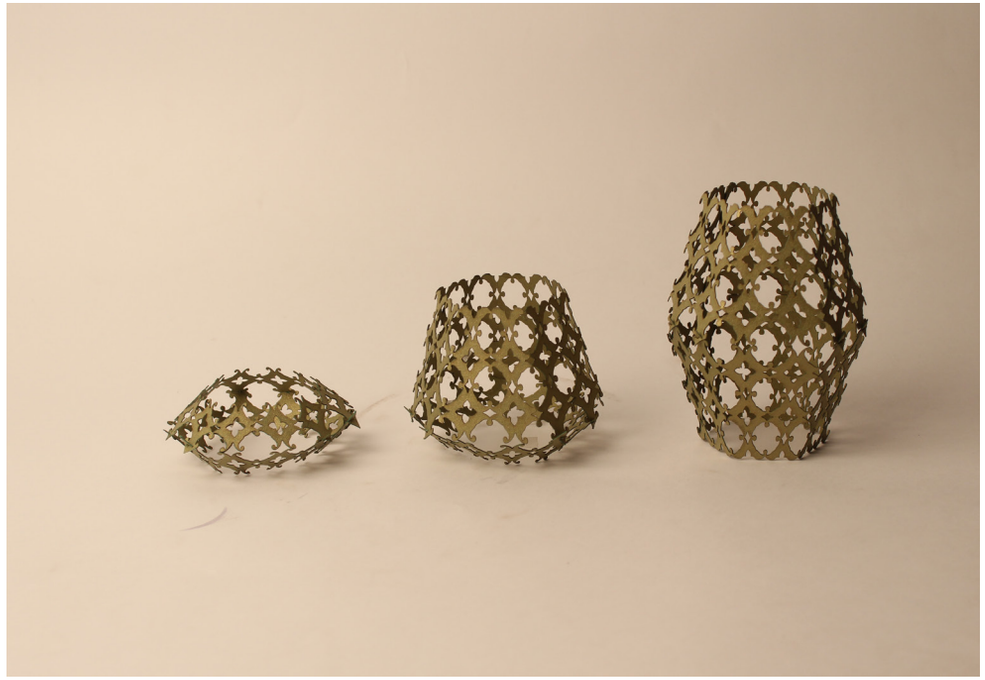
Each structure is formed by various small frustums. Each frustum element and it respective cut-outs has to be planned in the 2D development.

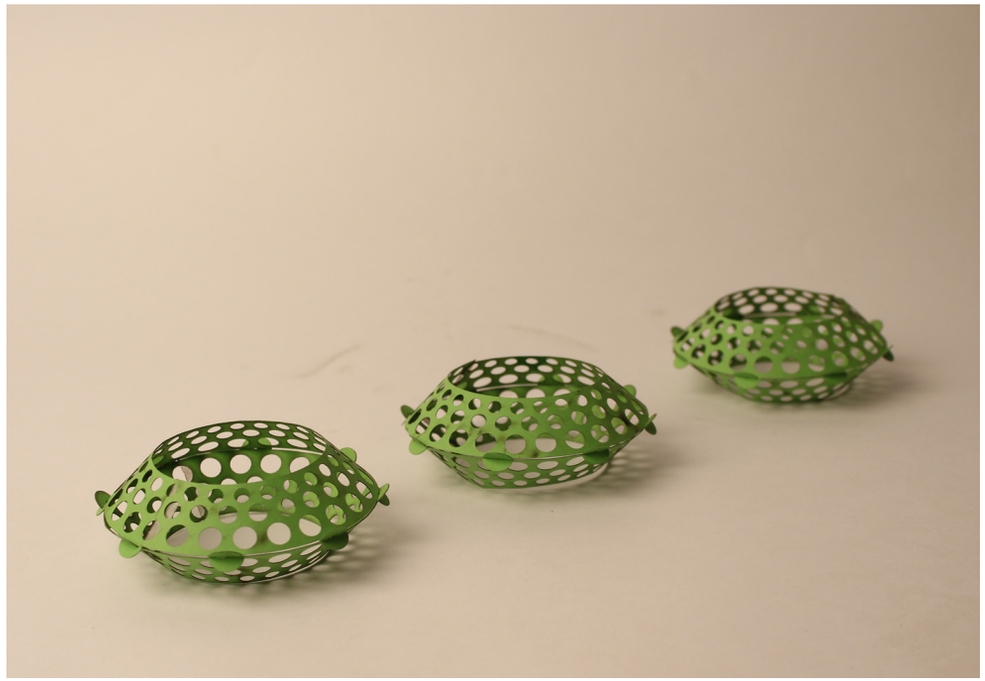
Thus the development drawing is cut and developed into mock-up

The process of development remains same wherever applicable, as the 3D structure is derived from 2D material

The drawings are then digitalised in and exported for laser cutting.

These unit pieces are locked in slots which fits together due to friction between contact edges and surfaces.





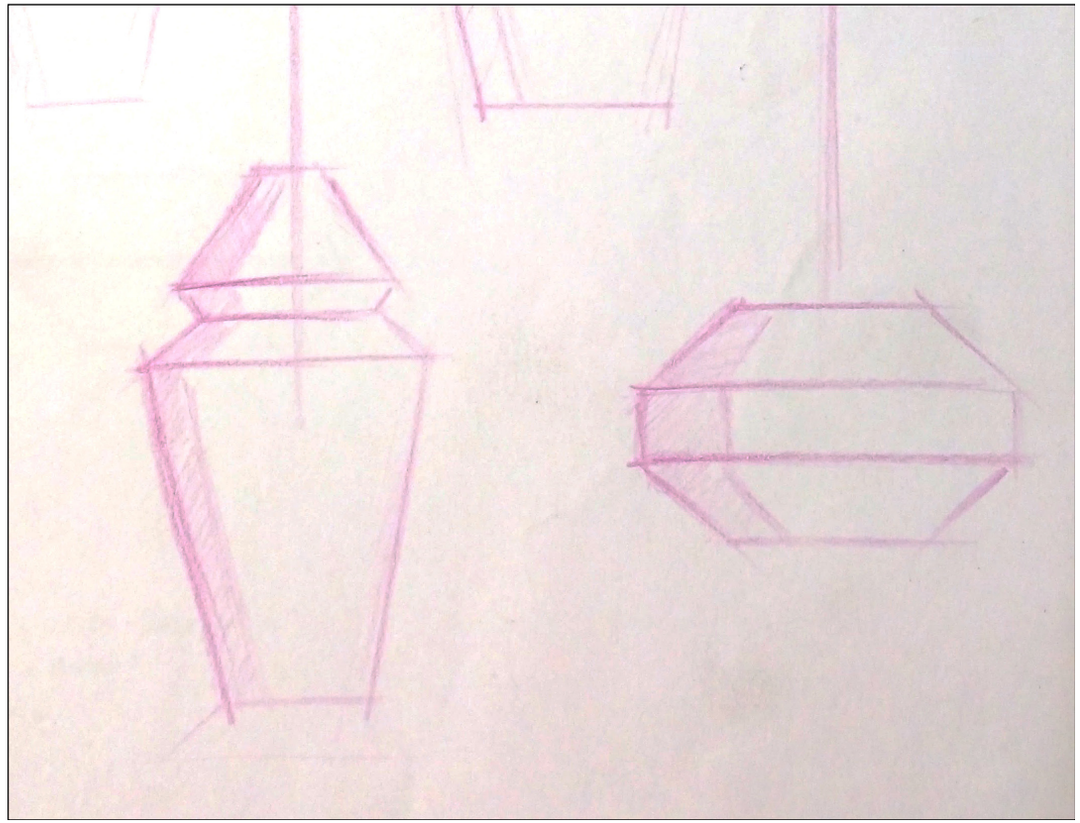
Observation
The base with least angle gives sharper shadow. As the angle increases, sharpness decreases.

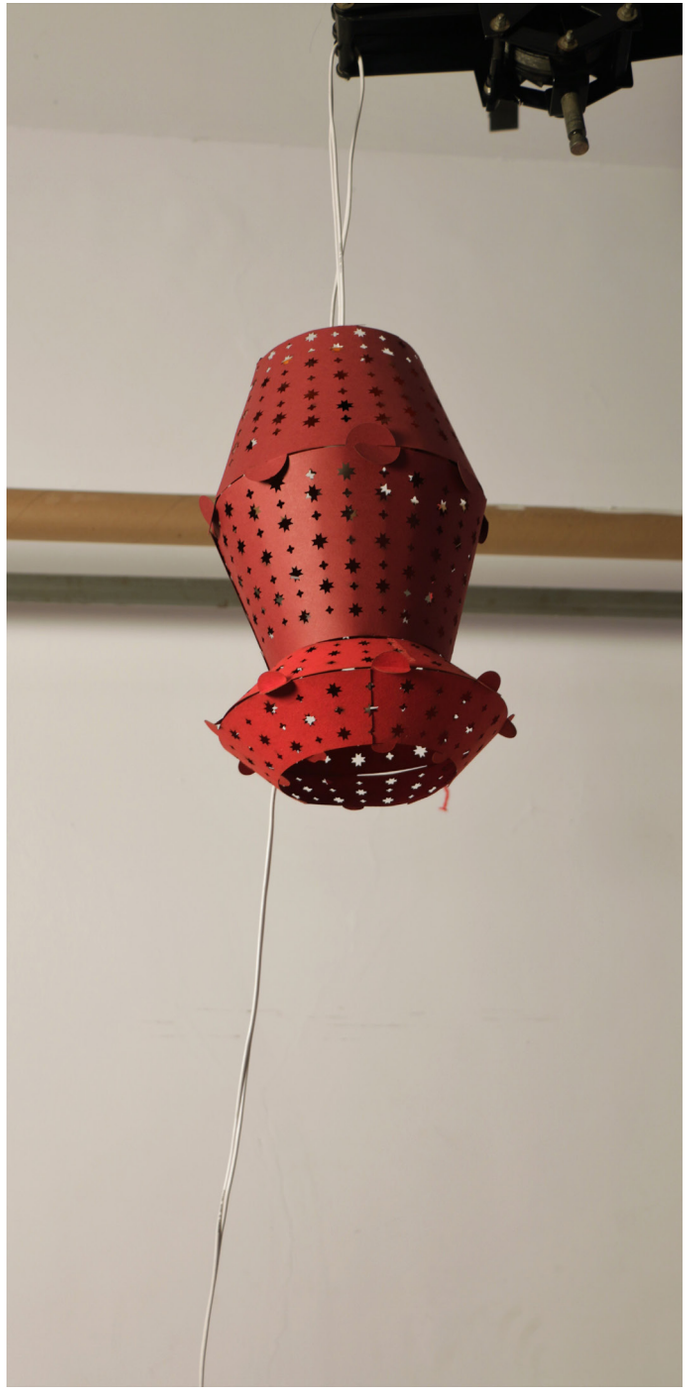
Insight
The shadow is sharper if the subject is closer to the screen and vice versa. The base with least angle is close to the screen(floor). And one with relatively higher angle cast lighter shadow with reduced sharpness.

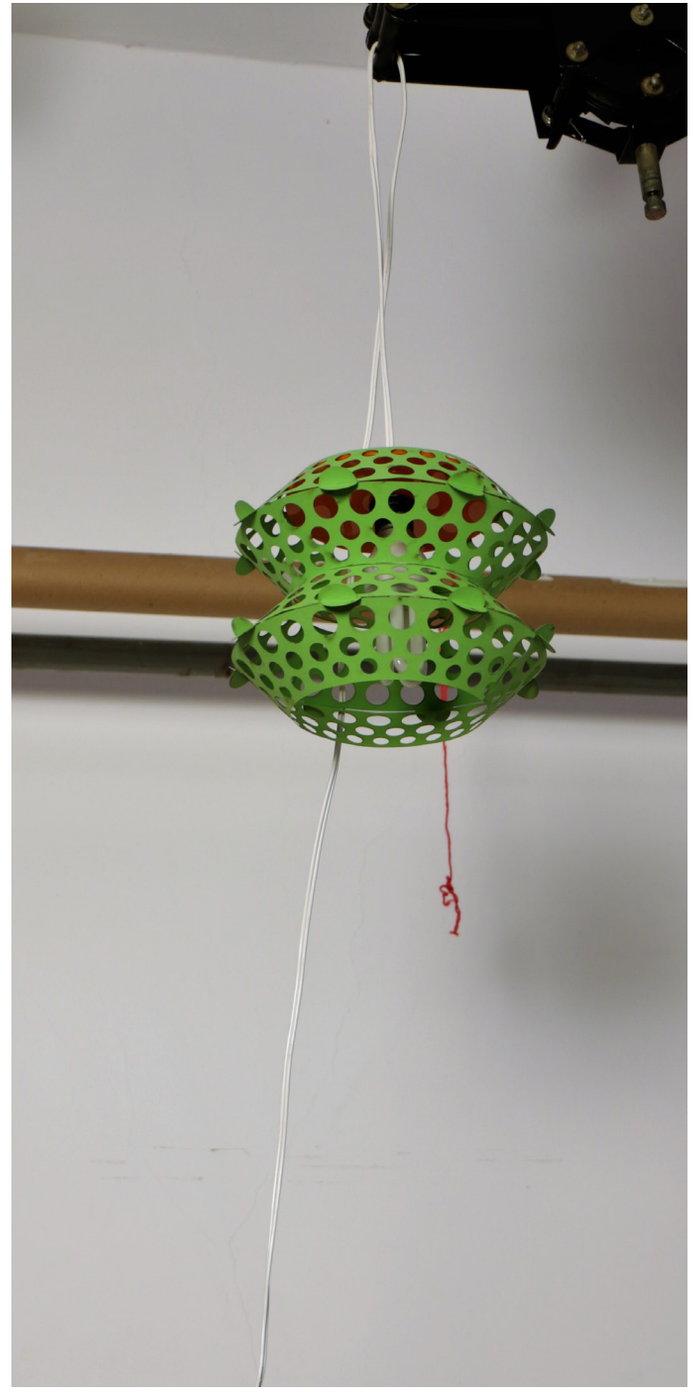
Exploration 2.2

As smaller size lamps are suitable for candles, bigger size lamps were explored and studied with electric bulbs as light sources.

The forms developed in prior explorations were scaled into bigger sizes and used as pendent lamps.

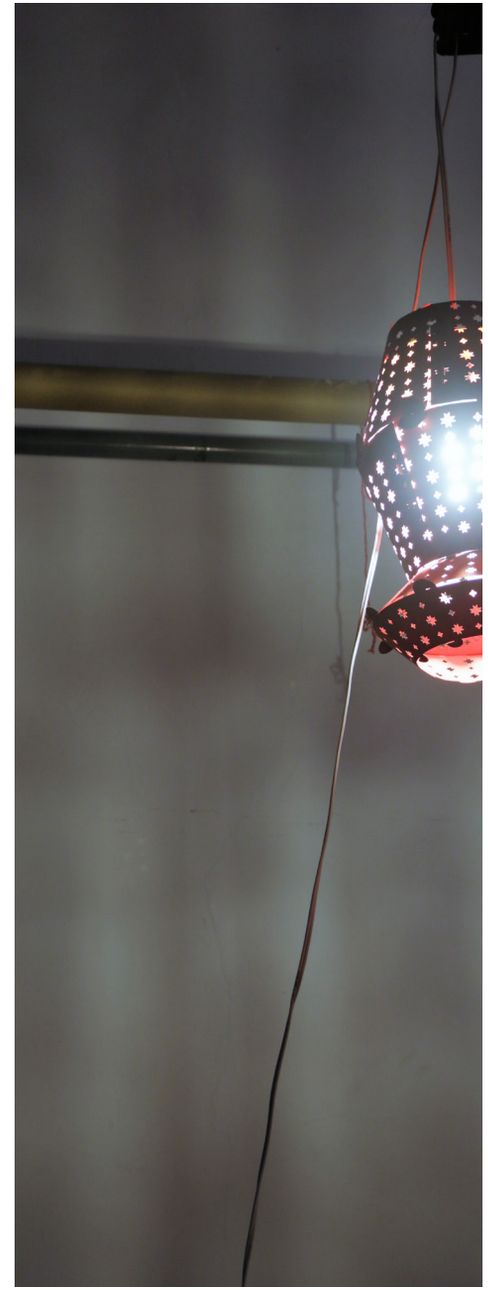




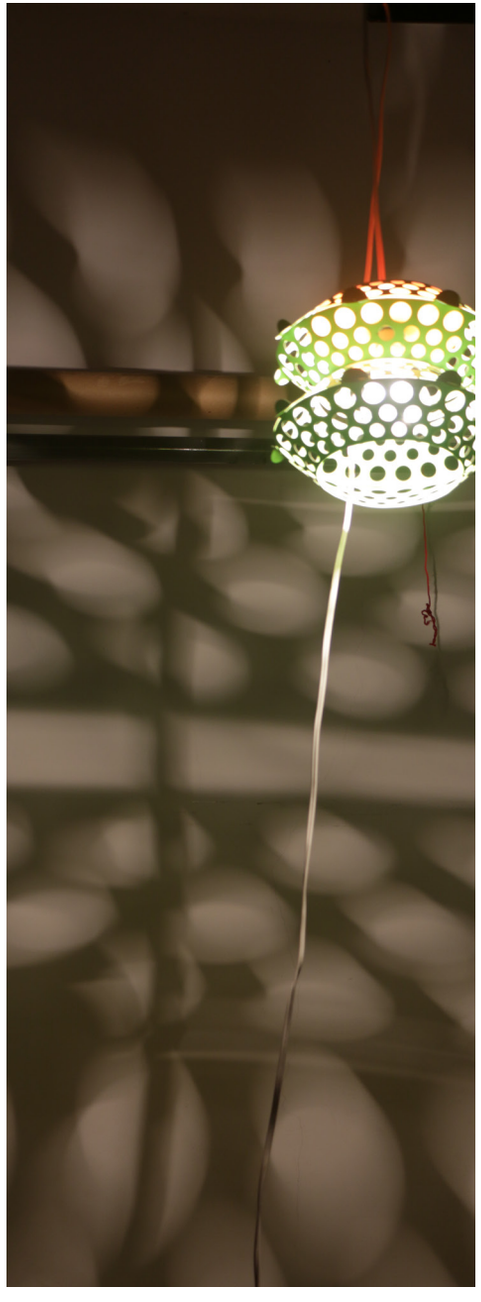


Effect of Incandescent Bulb

Effect of LED Candle Bulb



Effect of CFL Bulb



Effect of Incandescent Bulb

Effect of LED Candle Bulb

Effect of CFL Bulb

Observation

Incandescent bulb produces multiple shadows, CFL produced no shadows, Candle LED produce relatively sharp but dull shadows.

Insights

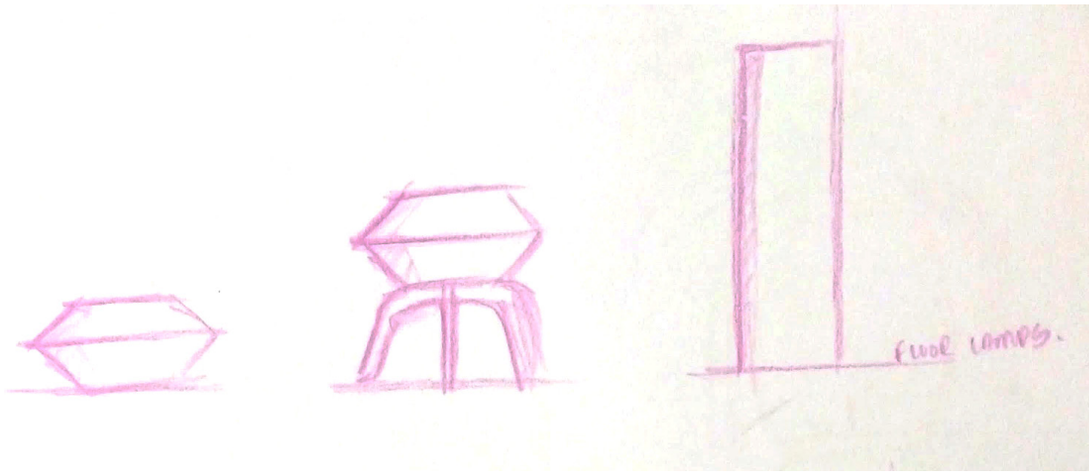
For sharper shadows, the light source must be point source and not distributed. A candle is a point source which produces sharp shadows. The incandescent bulb has its light source distributed over a filament and hence produces multiple shadows. CFL and LED bulbs have distributed as well as diffused light source and hence produces soft shadows. Since the candle LED houses one LED as light source acts as point source and hence produces relatively sharp shadows but since it uses LED of low wattage, the light intensity is low and appears dull

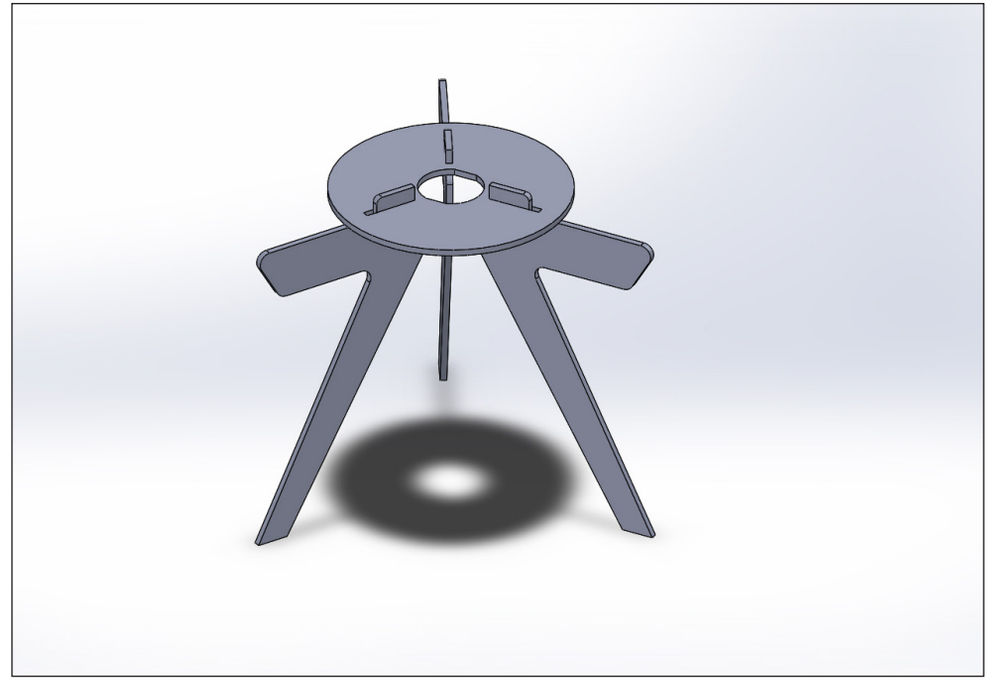
Exploration 2.3

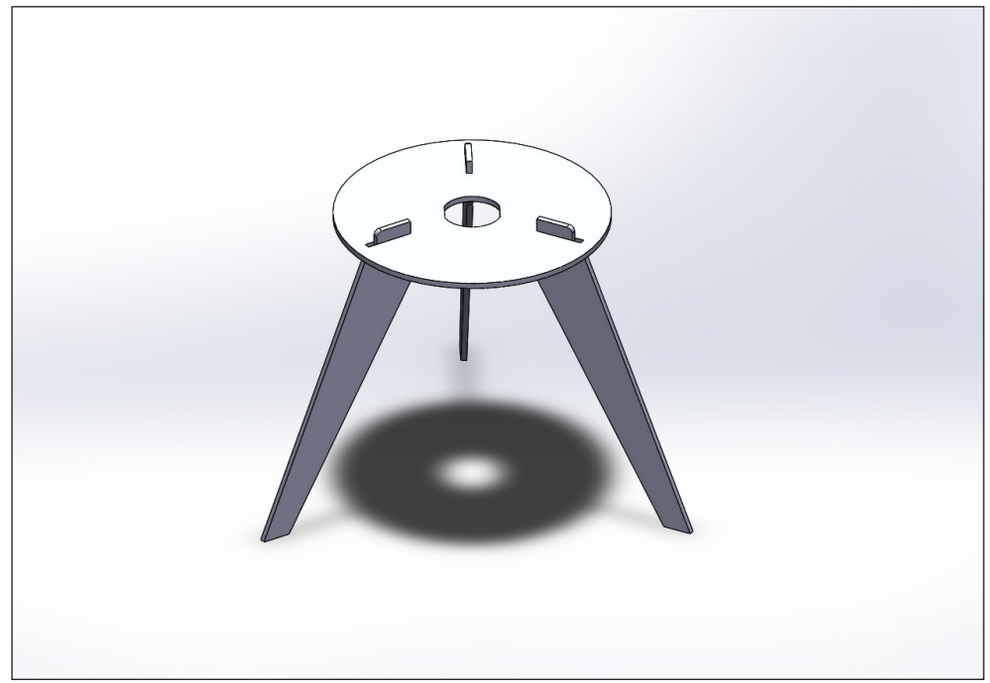
What happens when the same lamp are used for table/floor lamps? Pendent lamps are supported by suspension and are away from the wall(screen). Whereas Table/Floor lamps are used supported by a structure and kept near the wall(screen) and hence there was a possibility of sharper shadows.

As discussed, the pendant lamp setup which holds bulb is slightly different from Table/ Floor lamps. Pendant lamps are supported by the suspension structure, whereas Table/ Floor lamps are supported on a rigid base with heavy weight at the bottom.

A stand was developed which can go flat and can be assembled without any fasteners.

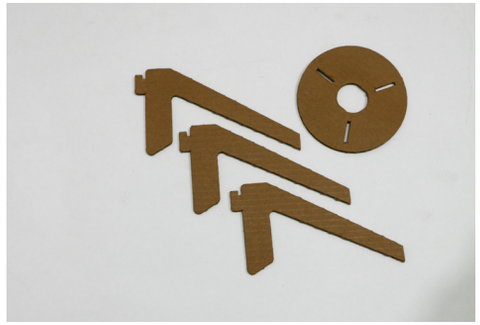


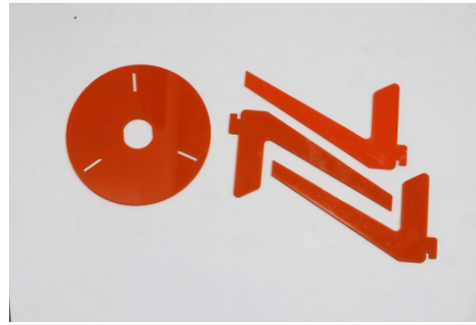


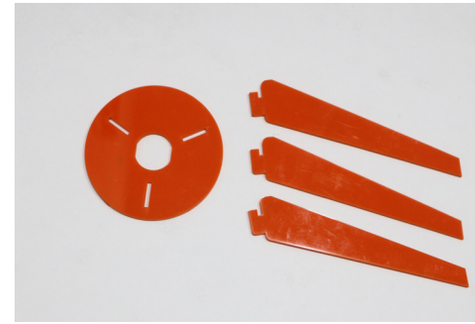


A mock-up stand was developed in corrugated sheet. The size of the hole was decided based on the size of bulb holders available in the market which is standard size.

Based on mockup, two types of designs were developed in CAD. These models ere further used for CNC cutting.

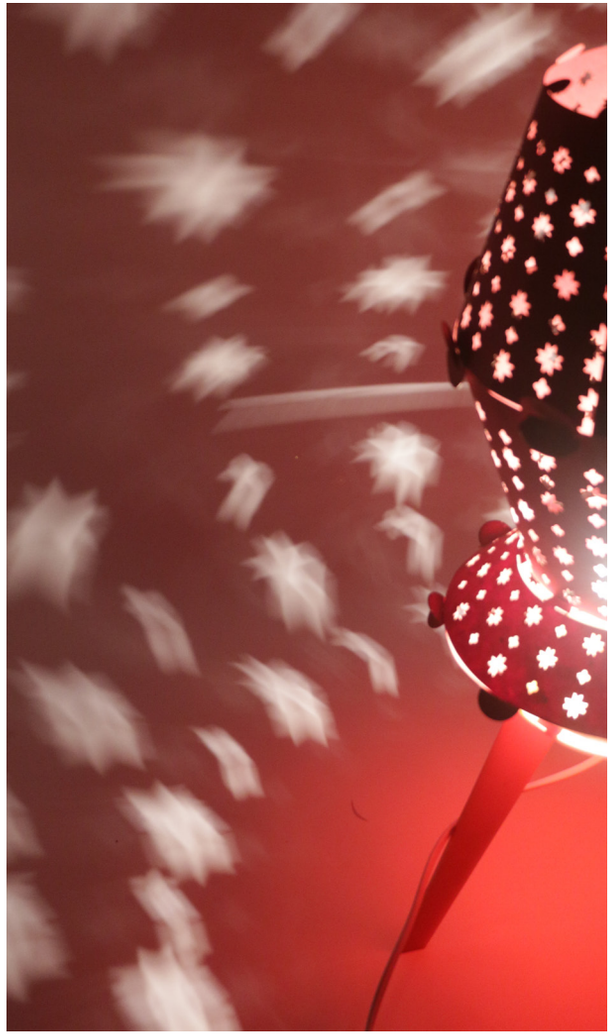






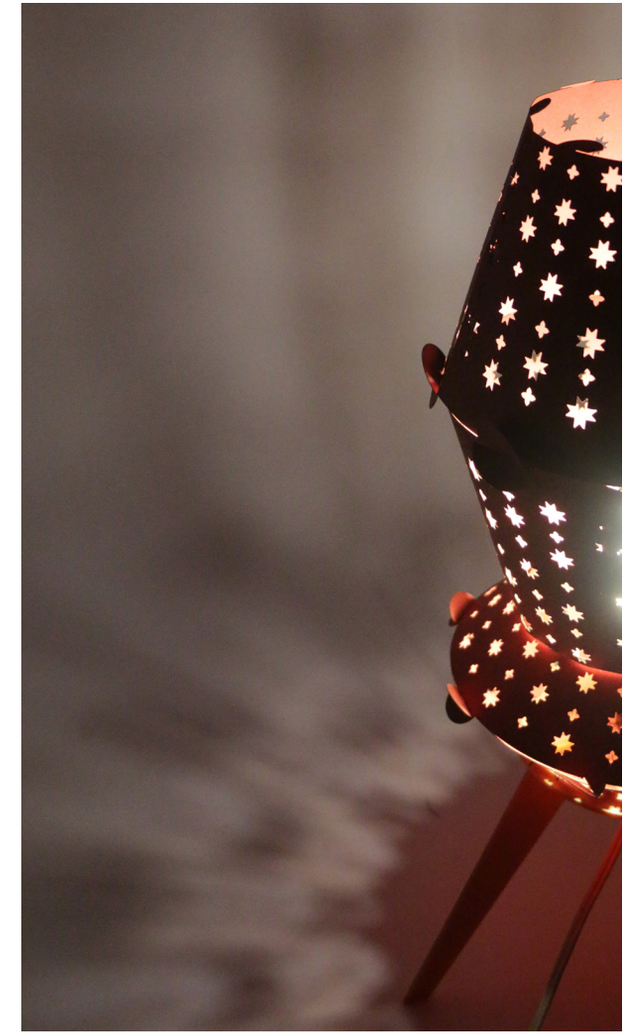
Initially the pieces were cut in corrugated sheet assuming it might handle the load. But after few uses, it lost it stiffness and started bending and hence collapse of the structure.

The it was cut in Acrylic sheets by laser cutting machines.



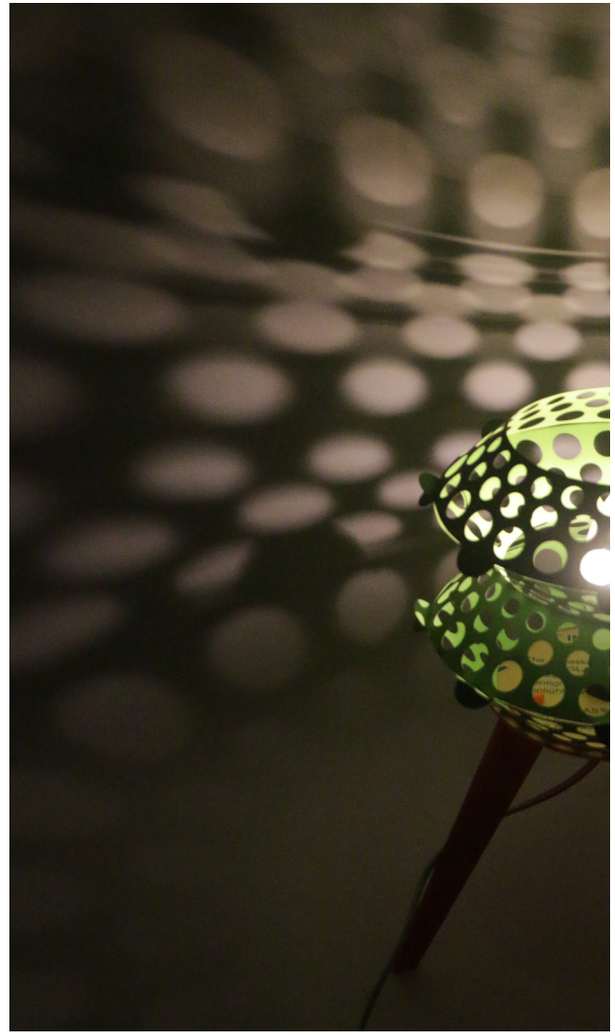
Effect of Incandescent Bulb

Effect of LED Candle Bulb

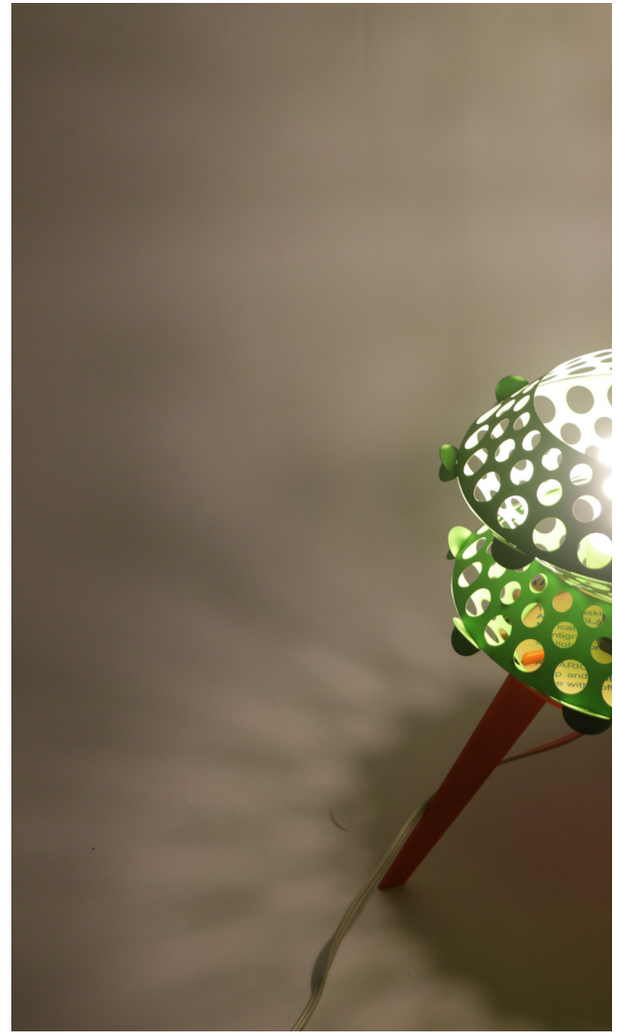


Effect of CFL Bulb

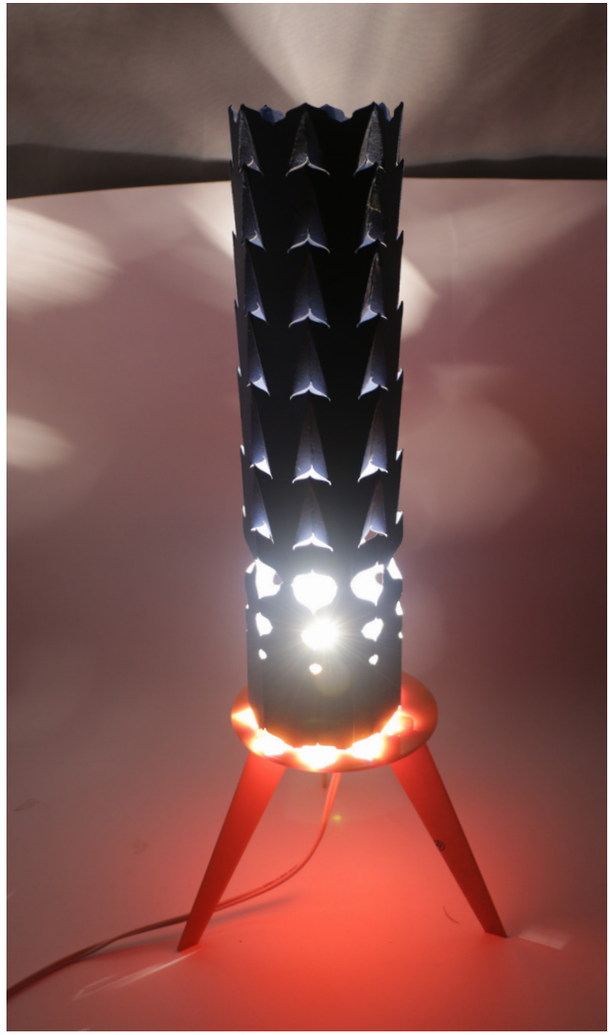
Effect of Incandescent Bulb



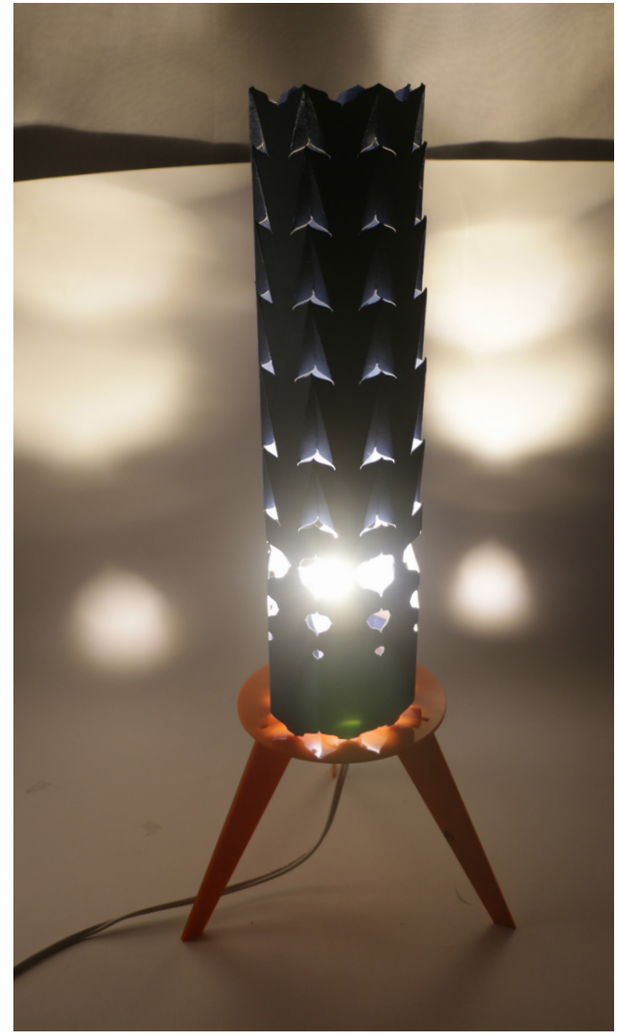
Effect of LED Candle Bulb



Effect of CFL Bulb



Effect of Incandescent Bulb



Effect of LED Candle Bulb

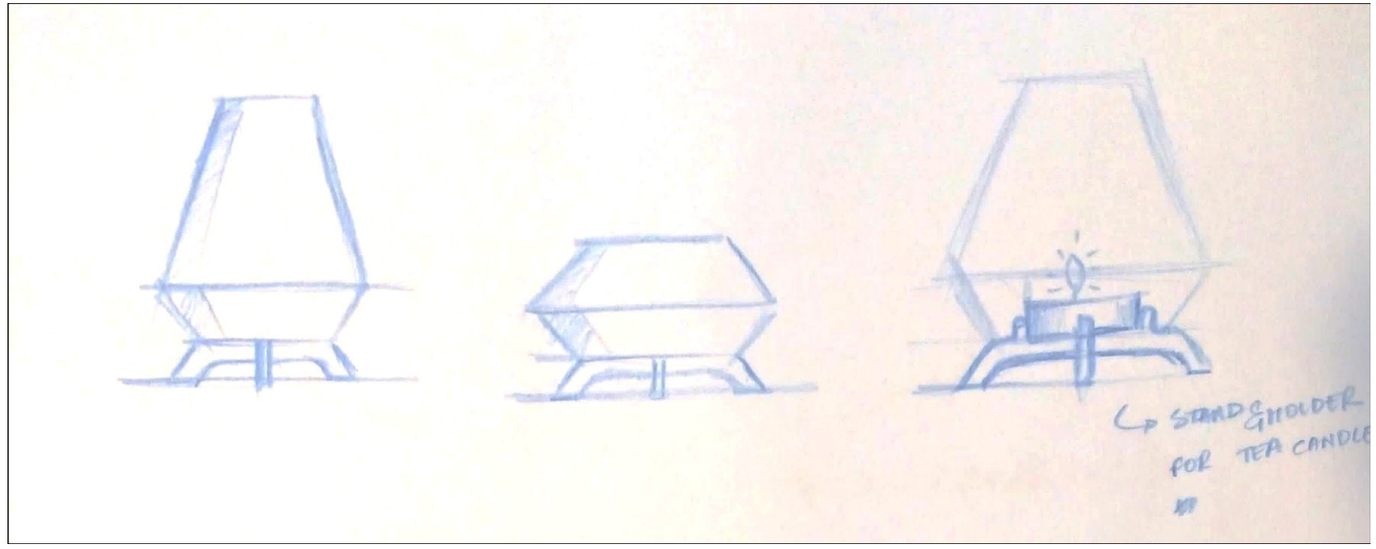
Effect of CFL Bulb

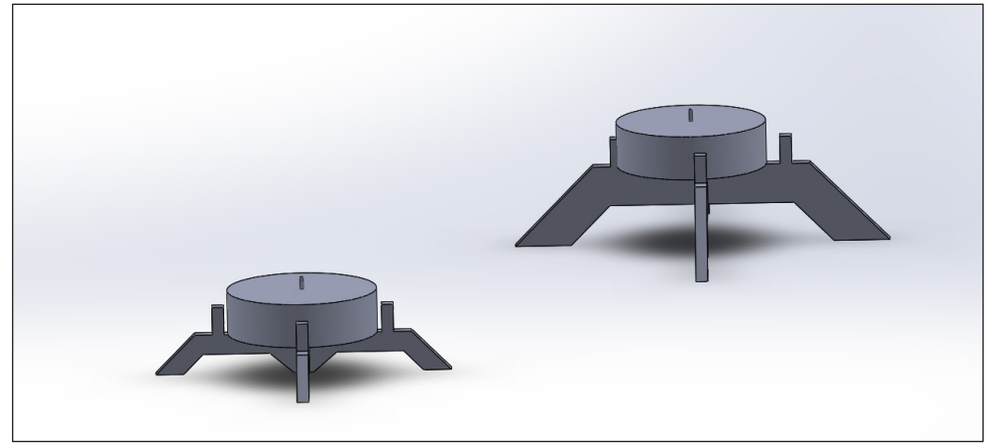
Observation

The sharpness of the shadow remains same as E2.1. Candle LED bulb produces brighter shadows as the light source is near to the screen. As the lamps are perforated, the light source are visible for naked eyes and produces glare effect.

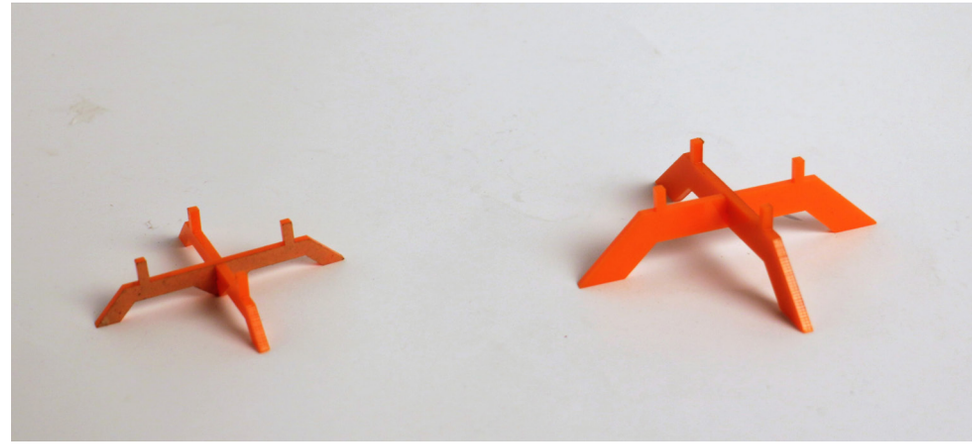
Exploration 2.4

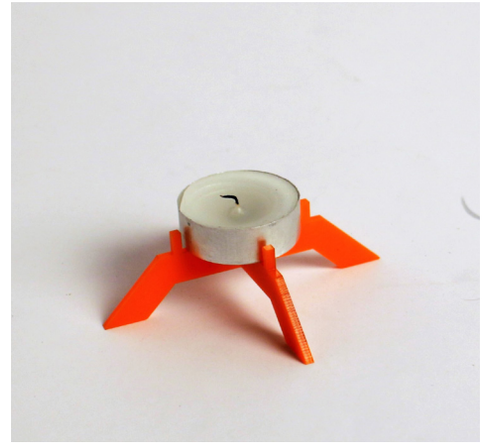
Inspired from the stand developed in E2.3, which resembles ancient lanterns, same was adapted to smaller candle lamps in E1.1, which helps to change the height of the light source.





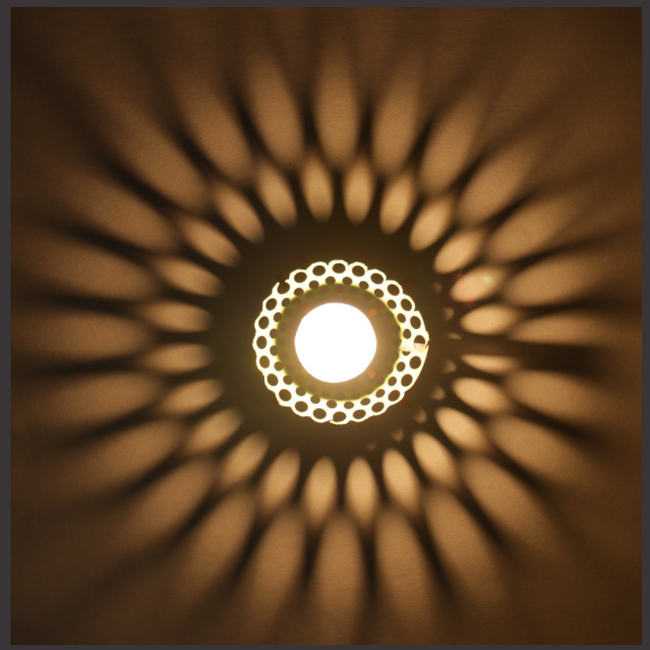
Two stands of height 10mm and 20mm were developed. This helps to understand the effect of height on shadow in 3 steps.









Observation

As height of the lamp and light source increases, the size of the shadow radially increases but the sharpness decreases.

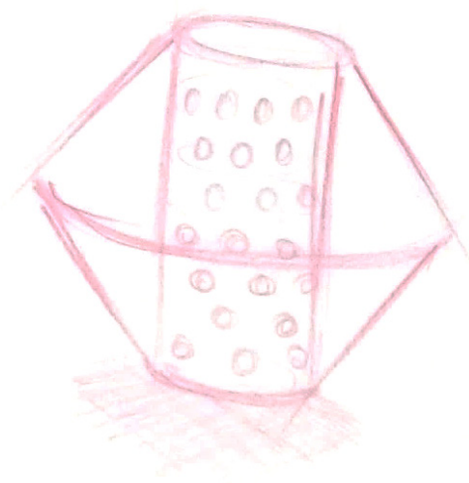
Insight

As height of the lamp and light source increases because the subject(paper lamp) is getting away from screen(floor). This is the same reason for the reduction in sharpness of the shadow

Exploration 2.5

This is lamp a lamp designed by MILK DESIGN studio, which uses single sheet of bamboo paper, which nicely folds at the top to produce nice form. I tried to use this similar construction on both sides.

Design by Milk Design



Observation
The subject itself acts as screen

Insight
The main advantage of this construction is - any cylindrical frustum shaped structure can be formed by a single sheet of paper. As the subject acts as screen, another perforated subject can be introduced (between light source and the screen) which projects its elements on the screen.

Exploration 3

Exploration 3

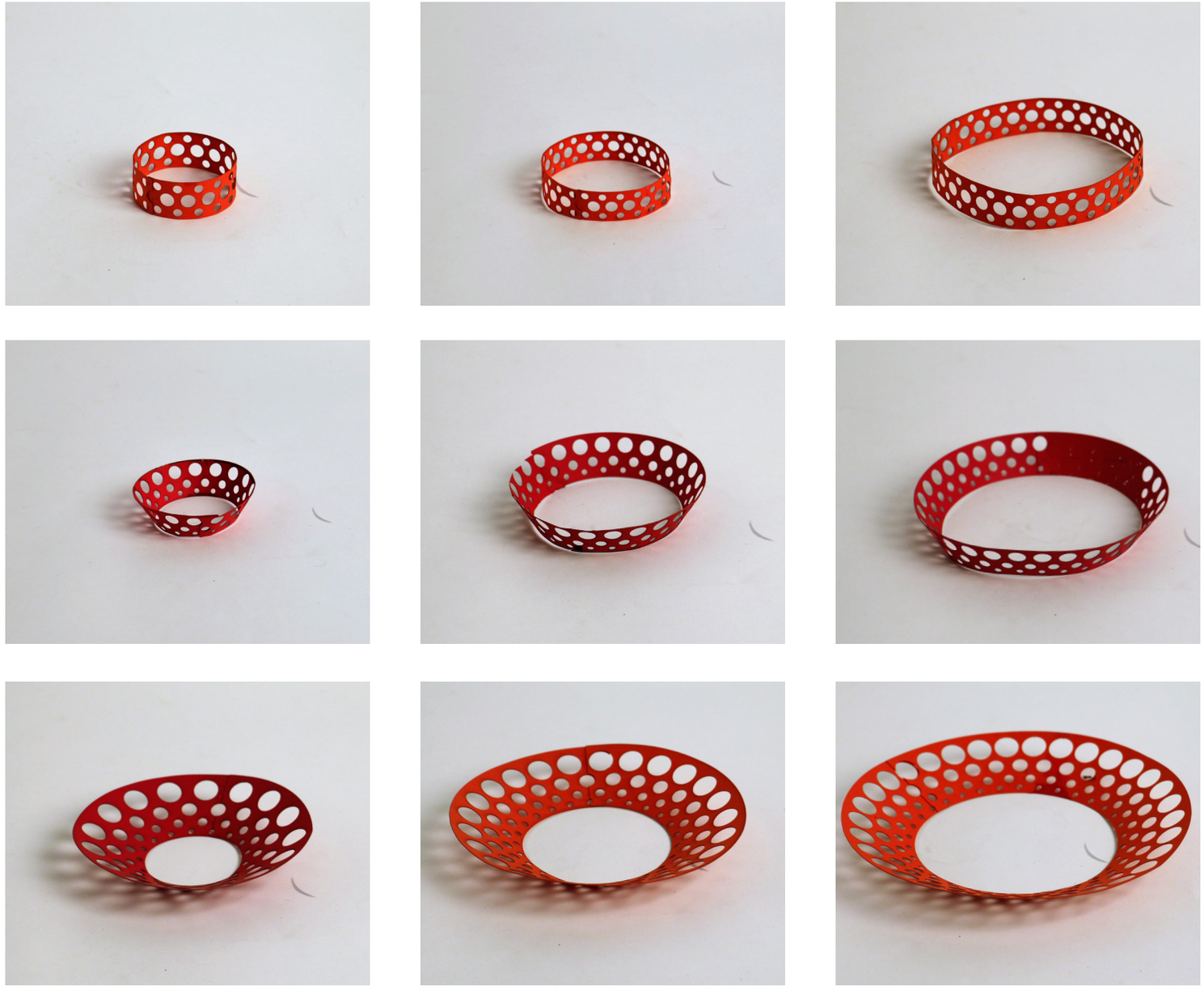
Prior two exploration sets primarily deals with the understanding the behaviour of light & shadow by altering various parameters. Every concept came out of those explorations are capable of leading into finished products, out of which two are already a finished products. The project needs to converge into a final tangible idea.

After an overview on all possible explorations, it was decided to continue with tea-light candle as light source due to many reasons. As the project explores shadows, this is the one light source which has produced sharp shadows compared to any other tested light sources. Candle has a warm natural light. It offers simplicity in nature as well as construction. I need not to worry about the constructional details which were involved in other concepts such as pendent or table lamps, as it was never the focus of the project. Pendent and table lamps on similar lines already exists, developing those will just add another similar lamp to such list.

Similar to E2.1, the base is chosen and its parameters are altered. The parameters chosen in this case are - Angle, Radial distance and height.

Circle is chosen as cut-out element so that all the lamps have same element. This exploration was mainly intended to limit one common idea and study possible variations by changing parameters and understanding their resulting behaviour.

Distance →



Angle →

Distance →

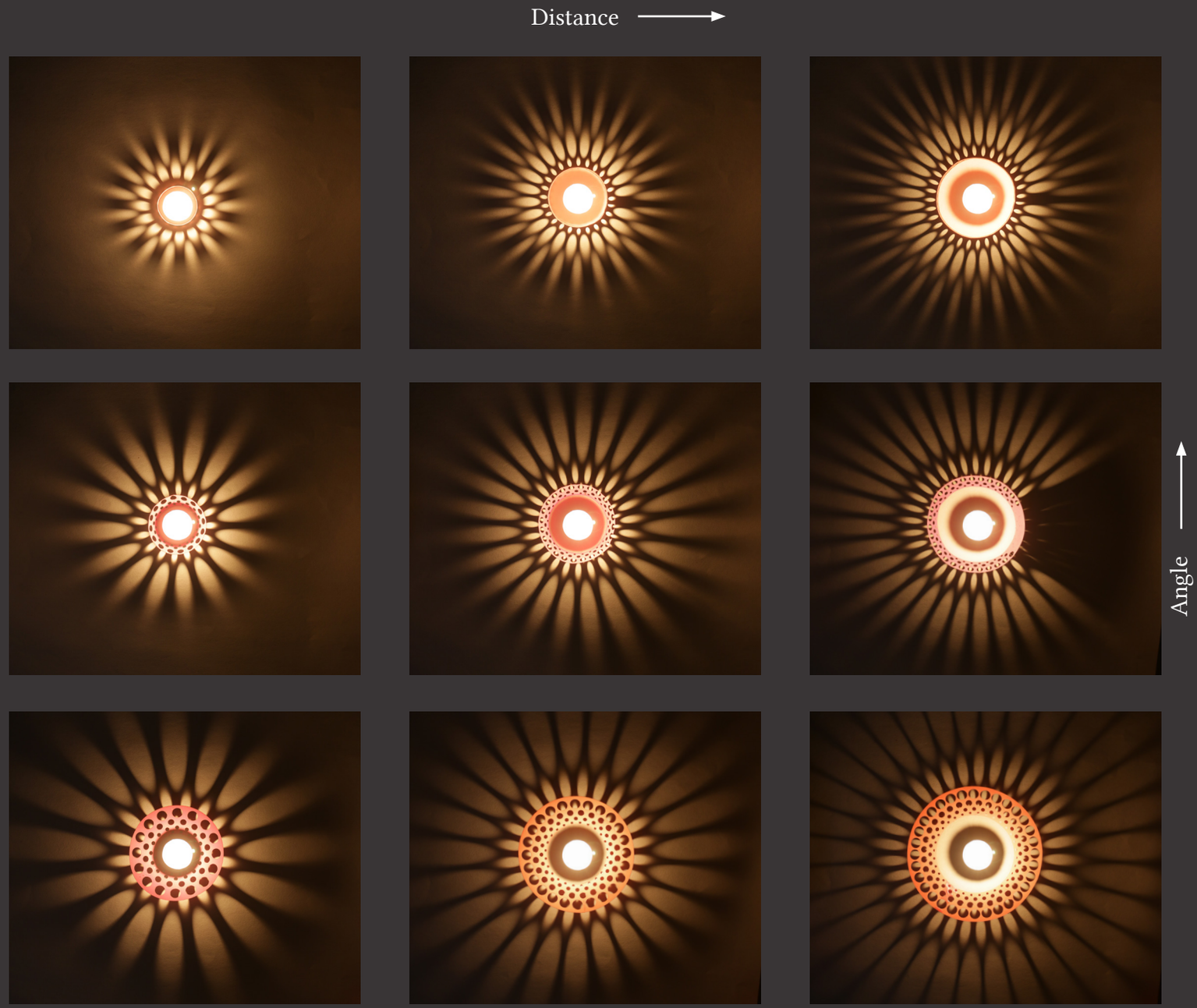








Angle →


Distance
Angle


Distance
Angle


Angle

Design Concept

Exploration leads to discovery and this repeated series of discovers leads to understanding and based on this understanding leads to design. Explorative projects are usually exhibited in the form of family where each member have a common character but still individual in itself. The family expresses the thought and understanding of the creator over a specific area such as the ability to create several different products and still try to keep common characteristics among the family.

On similar note, I was ideating various set of families. This is clearly evident in E2.1. Another idea was arranging the lamps in such a way that the whole composition turns into an interesting form like Rangoli. However these seems achievable, the tangibility factor of a final product was missing. These ideas might appear abstract to the audience and may not connect with the product. When viewed from audience perspective, the idea appeared as a collection of some paper cut-outs around candles.

It all connected when my attention was grabbed by chess pieces. All the elements fell into place. Basically chess pieces have a common visual language, i.e. they have a quality of family. Each piece have individual characteristic. Most importantly, it is understood by most of the people in the world. But the challenge was translating my understanding into the individual characteristics of chess pieces through light & shadow and form.

First I had to understand the chess pieces thoroughly in terms of shape& form as well as the value that each piece represents. The design consists of two parts. First and most important part is the base which is responsible for creating pattern. The same has to be designed for each pieces based on their individual characters. The second is the physical form of each pieces which could be shaped by paper.

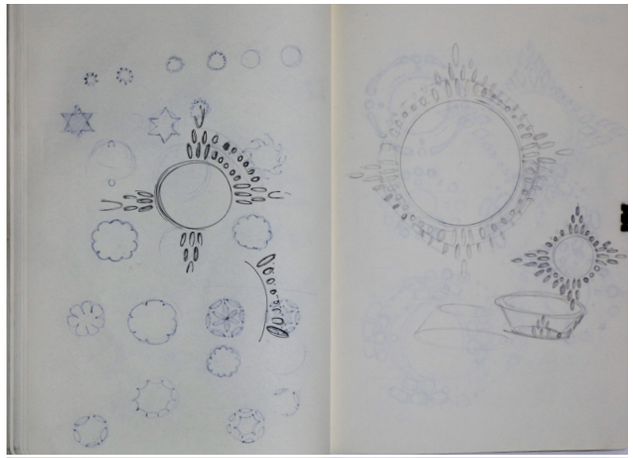
For this, I needed a visual library of different types of chess pieces created by various artists/ designers around the globe. Pinterest was the right place sourced me with enough images. The images being collected ranged from standard forms to abstract forms. Some of the notable designs were chosen and sketched for deep understanding of shape, size and form.

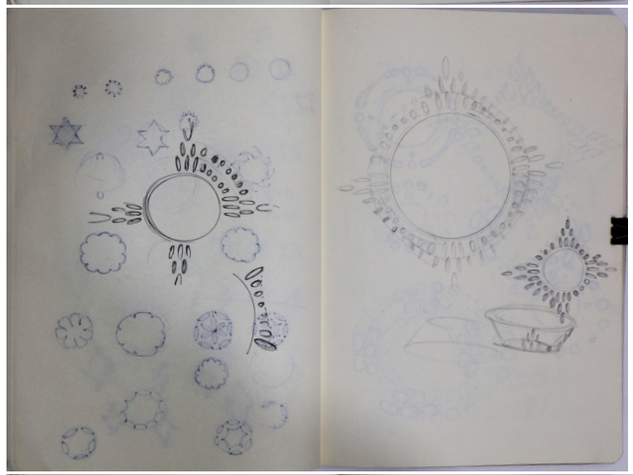
Translating characters through patterns

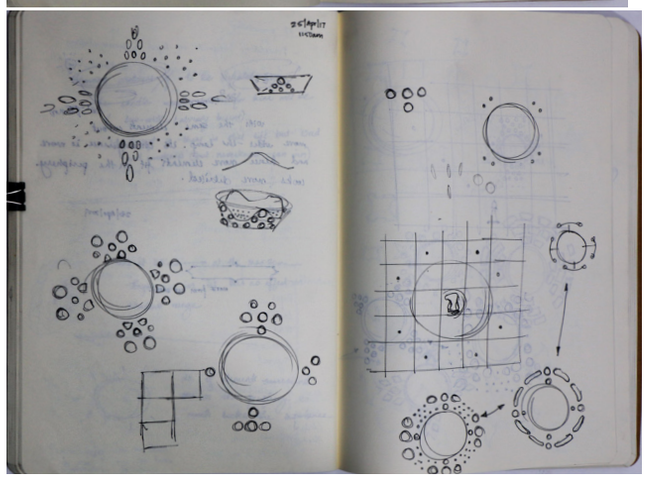
Each chess piece have a unique character, quality, power, value, position, direction, movement and degree of movement. Each chess piece have a specific value position which decides the importance of that piece in the game, however this changes as the game proceeds and depends upon the situation of the game. The value position of pawn is 1, Knight is 3, Bishop is again 3, Rook is 5, Queen is 9 and King is infinite. Pawn moves in one direction unless an opponent stands in adjacent square in diagonal direction. Knight moves in L direction, Bishop moves in diagonal direction, Rook moves in straight direction, Queen moves in both diagonal and straight direction. King can also move in any direction as Queen, but limited to one step.

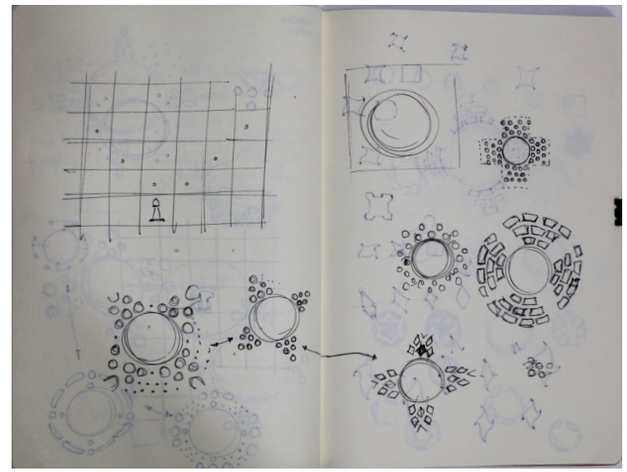
Based on these specific characteristics, the shadow is planned and designed based on prior understandings of exploration.

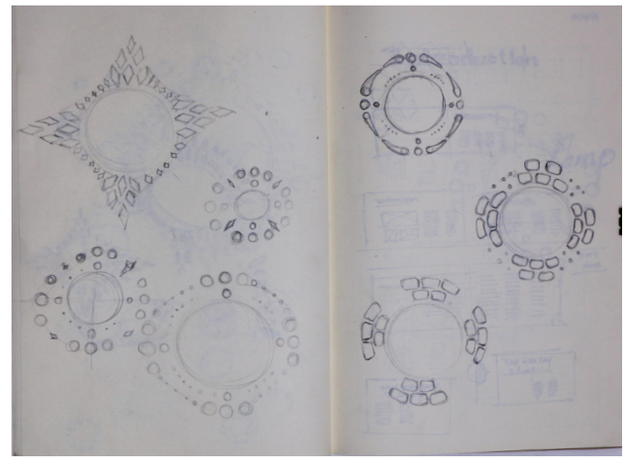
Ideating patterns

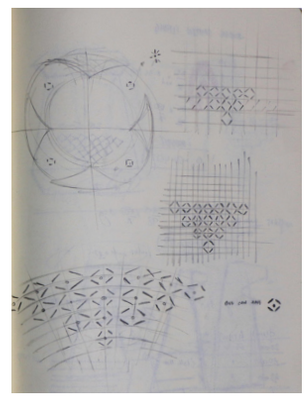












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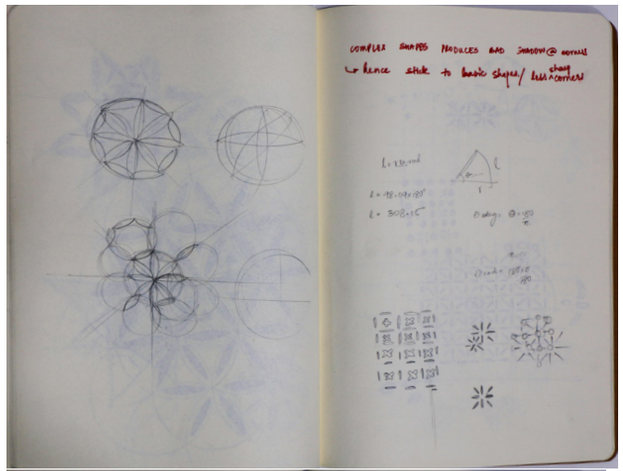
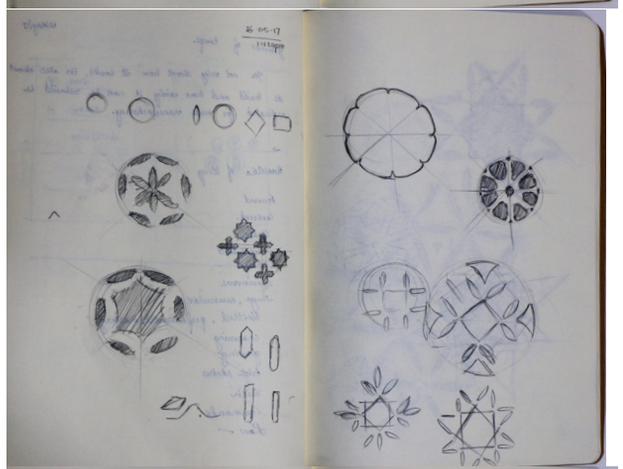
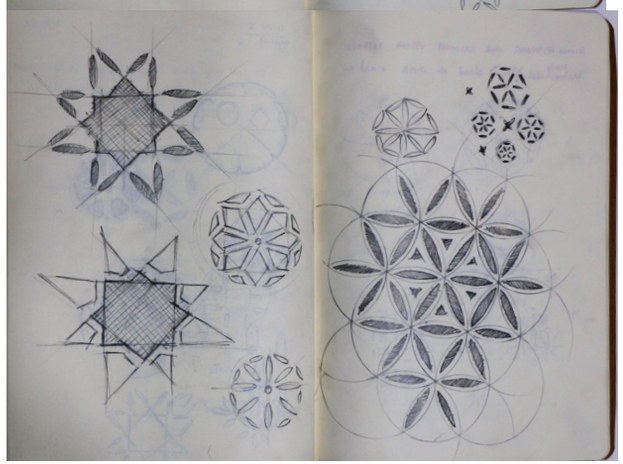
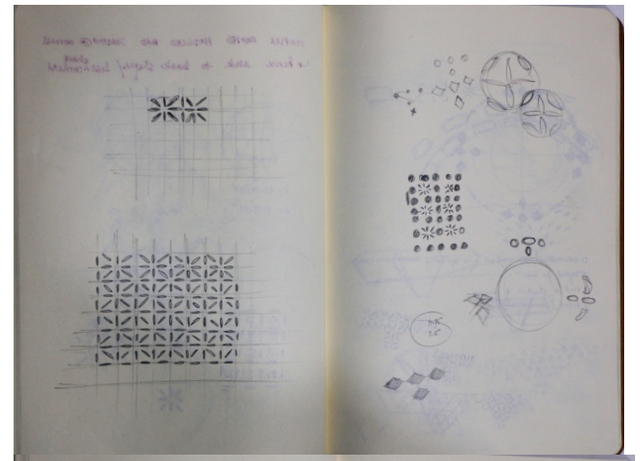
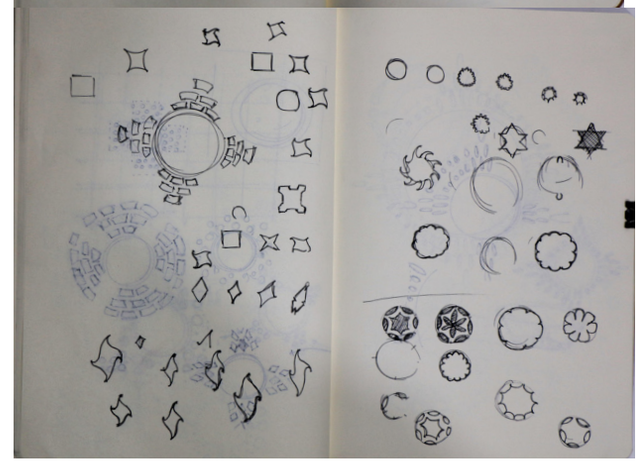
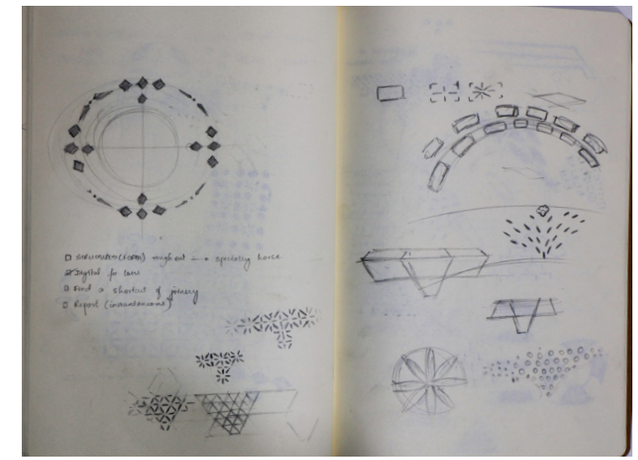


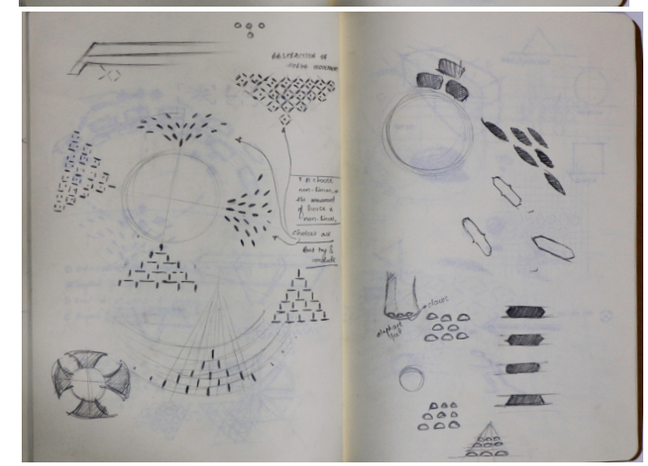


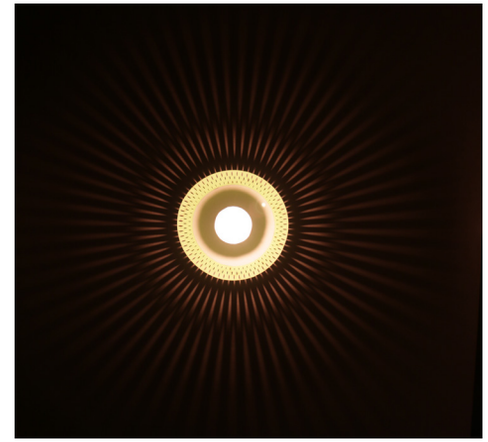








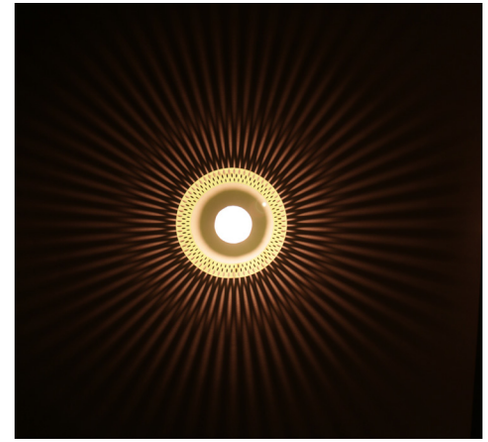


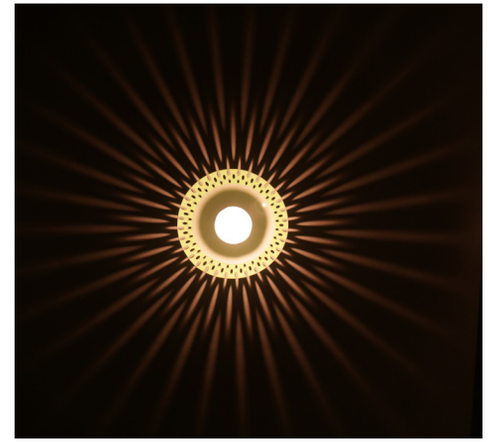


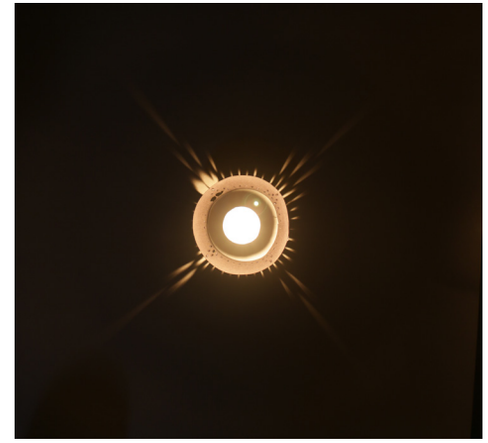
Queen

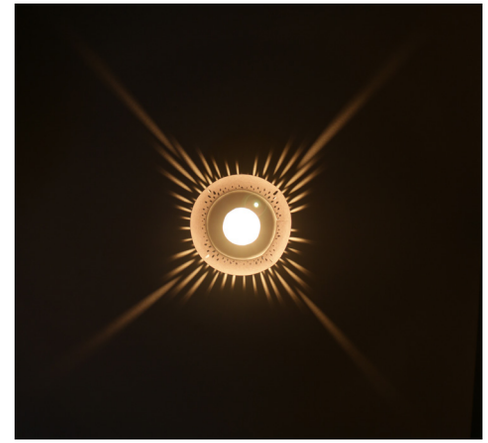
Queen has highest value next to King. And it is the only piece with maximum power in the game due it capability of moving in all 8 directions. The same is tried to visualised in the patterns, which shows its radiance in all directions which relates to its ability to move. The sharp and delicate strokes which form the whole pattern is relating to the power of intelligence.





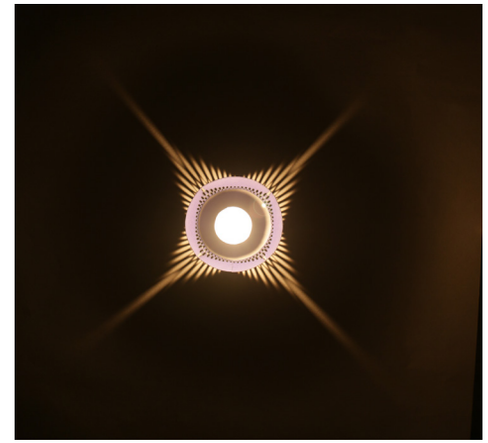


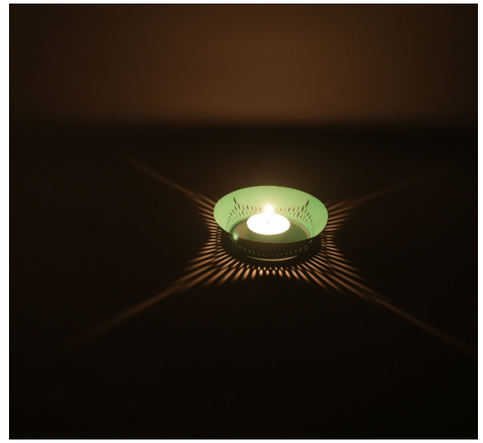
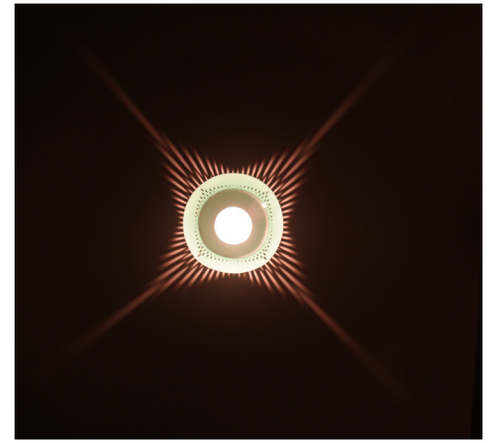
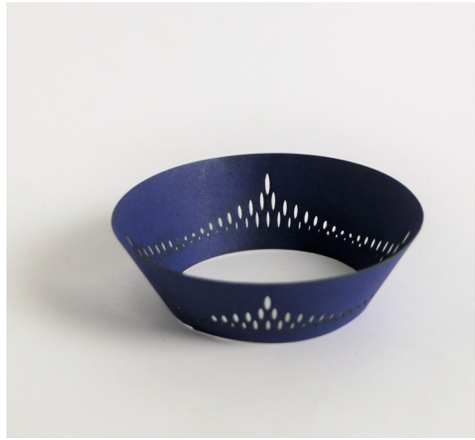


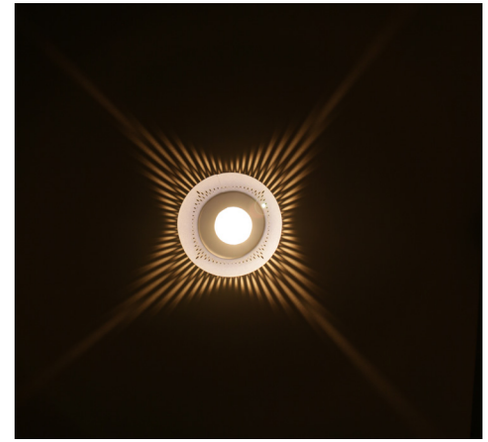
Bishop/ Camel

The structure of this pattern is built on the queen design. The camel moves in diagonal direction, thus the pattern is designed such that it communicates its movement. The nature of movement over the squares is sharp, lean, edgy. Hence tried to keep the thin strokes.





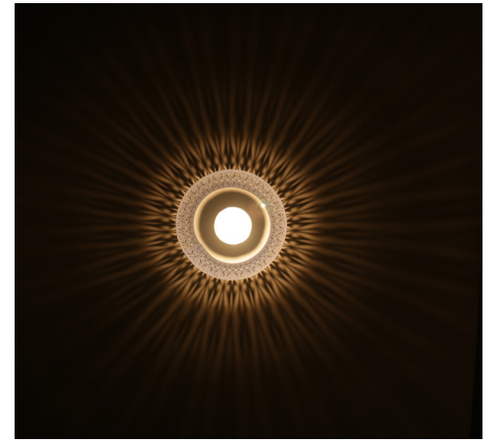












King

King is the most valuable piece of the game. However the king have very minimal movement, being King he has to be distinguished from other pieces. He must not only differentiable but also celebrated by all the richness he owns.

The last two pieces were characterised with one element of stroke radiating outside. Here, to add value and distinction, similar elements were added in different order along with radiating elements with some modifications due to which a detailed pattern is created.





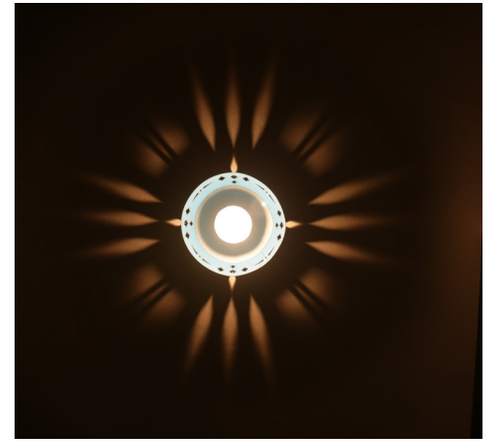


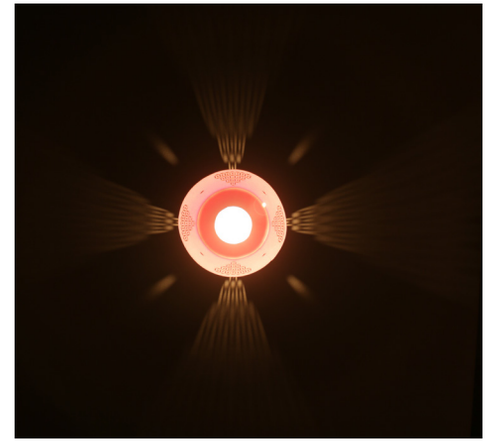


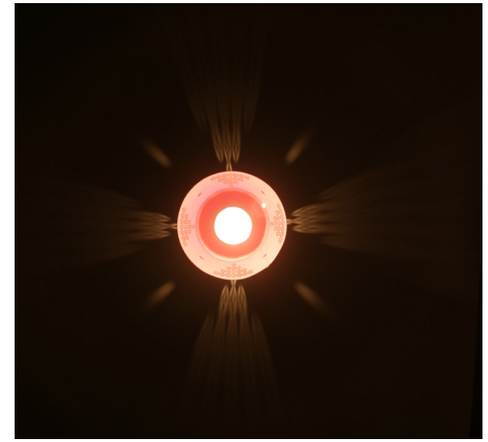
Knight/ Horse

Horse is the only piece which moves in non-linear fashion. It moves in L-direction. This pieces was bit challenging, as the direct interpretation of its nature of movement was not producing interesting patterns. After some iterations, a bit of abstraction was added to the initial idea to get the final pattern.

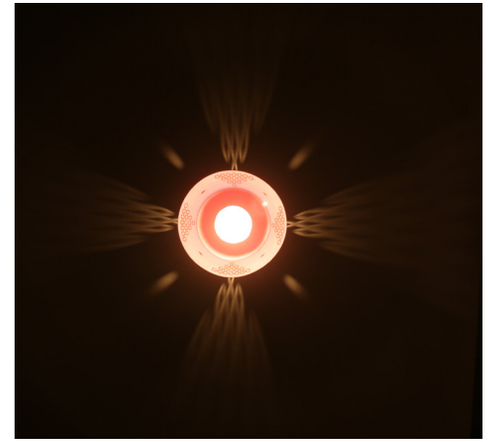


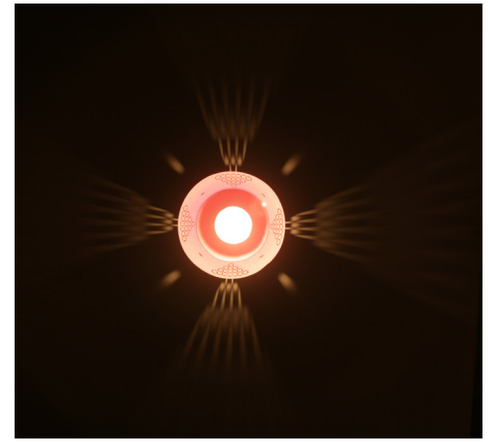




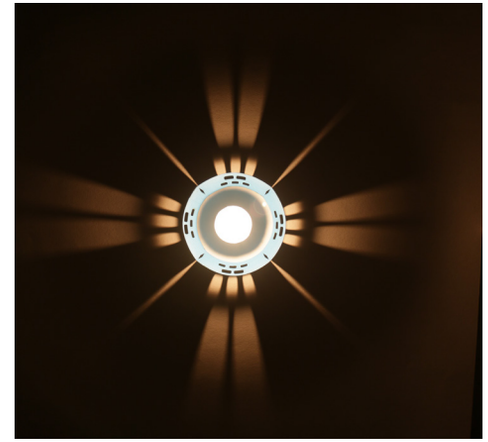


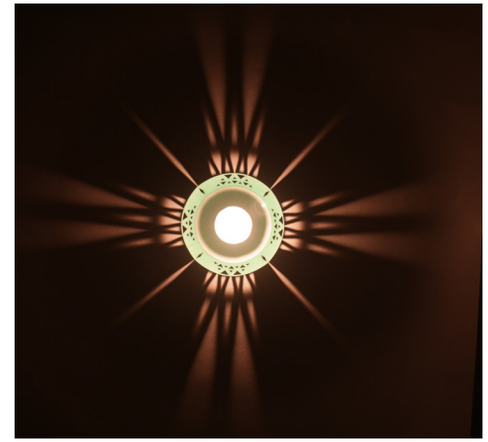



Rook/ Elephant

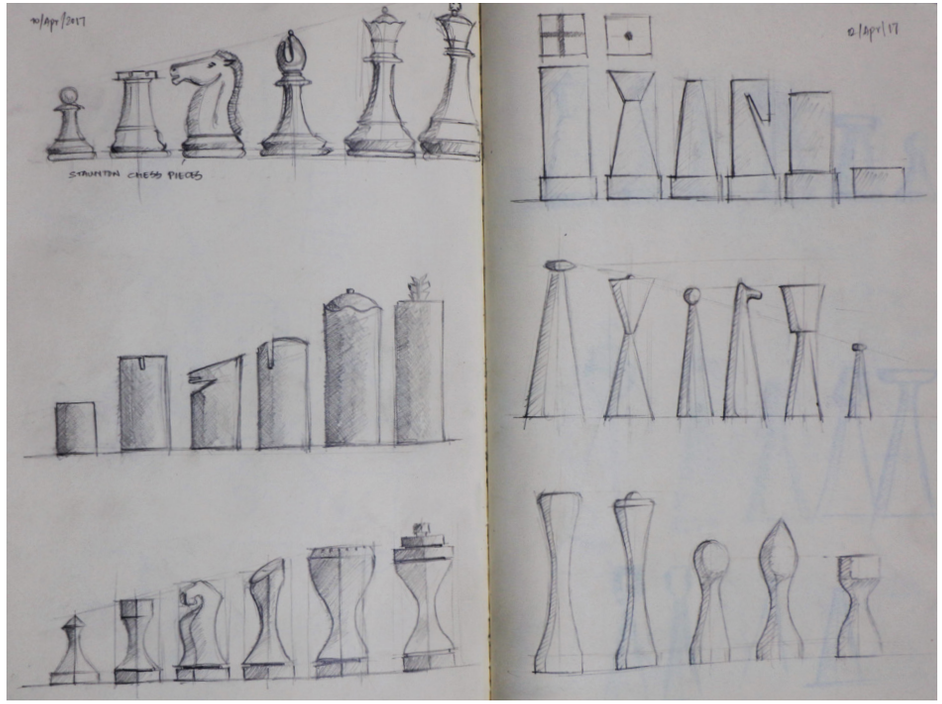
Rook moves straight ahead and is one of the strongest pieces. The nature of Rook is dominating, Huge, Heavy. This sweeps whatever in the path. The pattern visualised is broad and huge which resembles its nature.

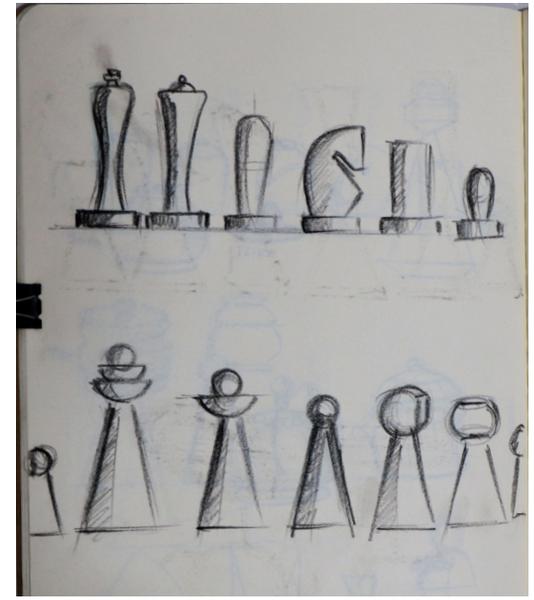


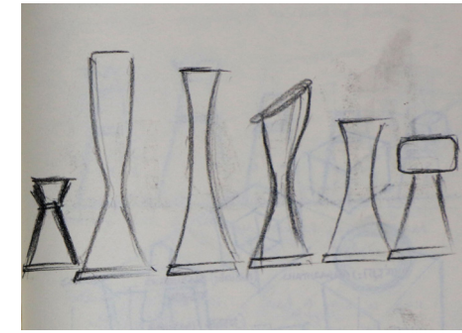


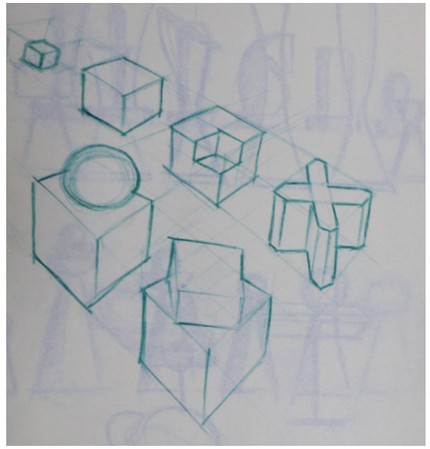



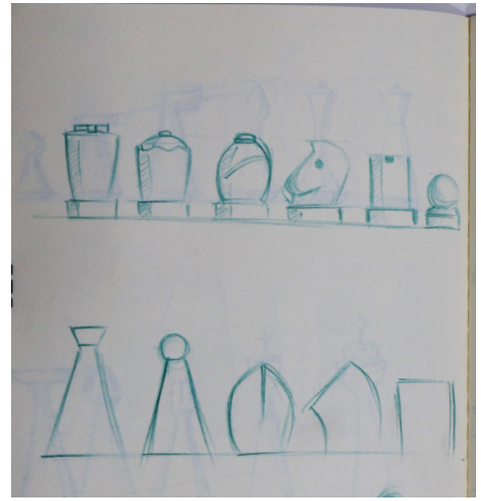
Understanding Forms

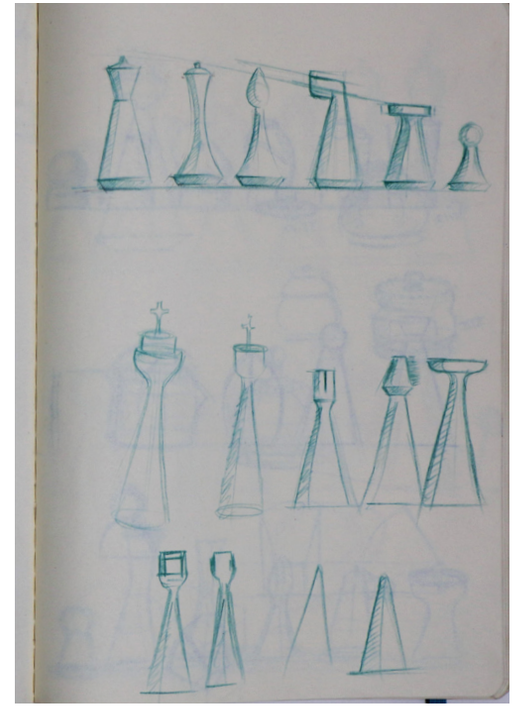


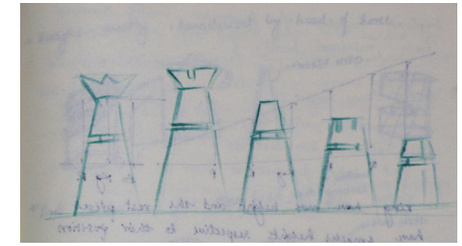




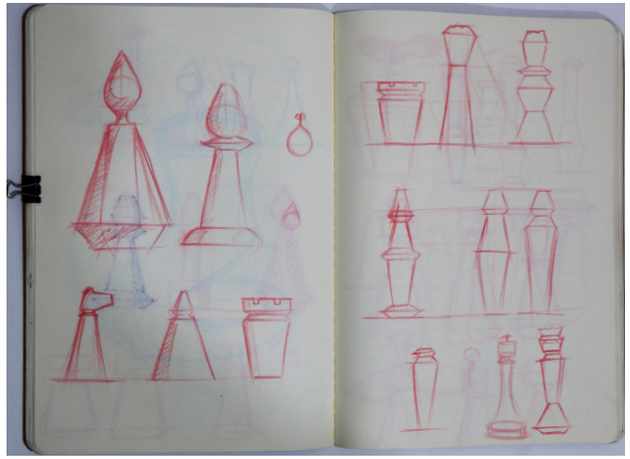


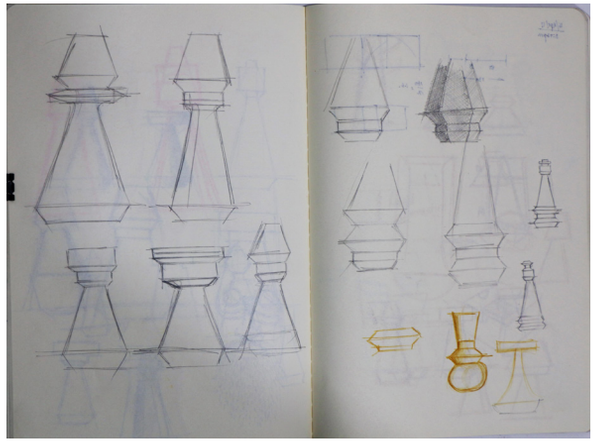


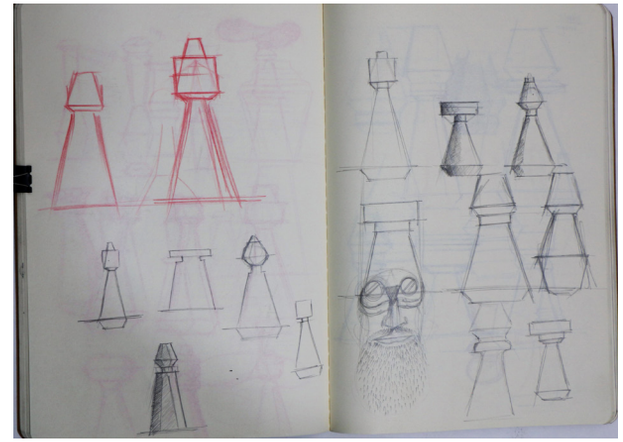


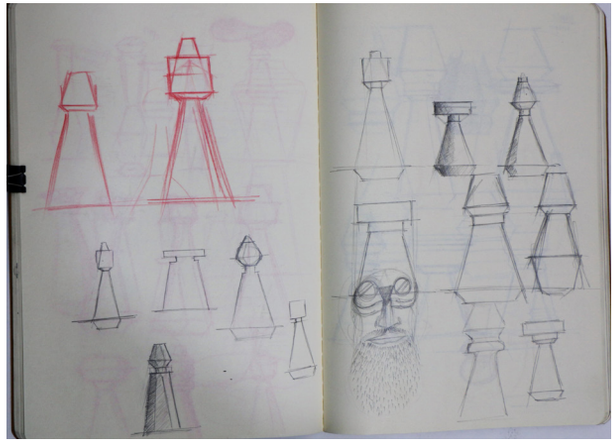


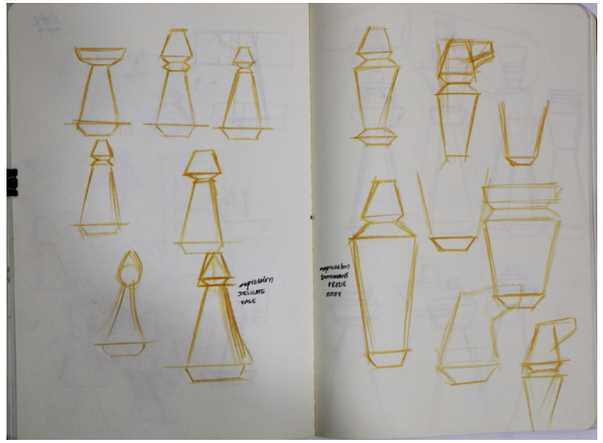
Exploring Forms

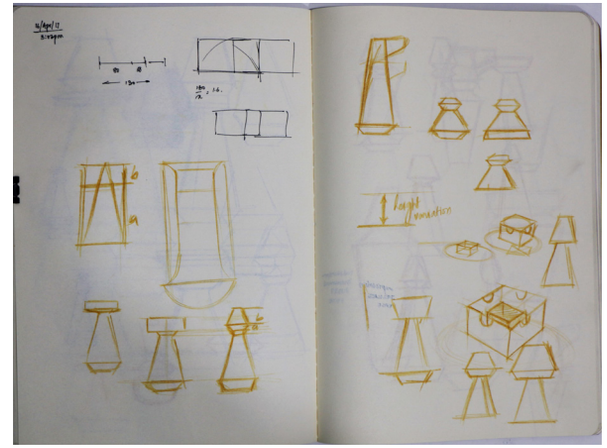


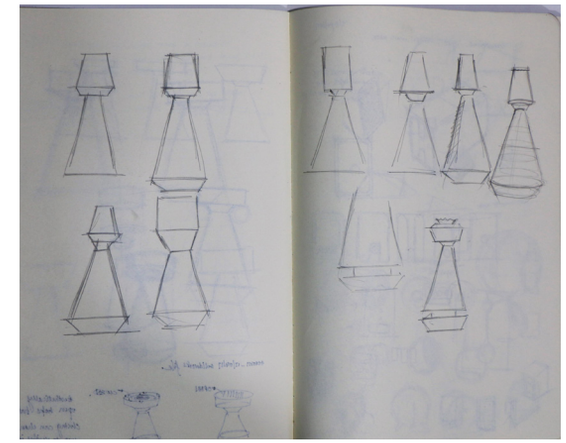


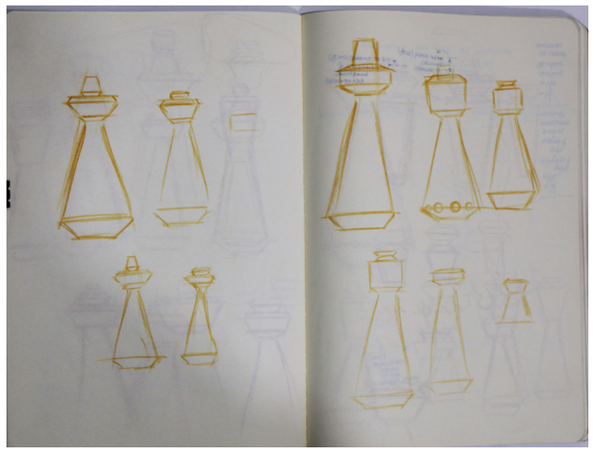


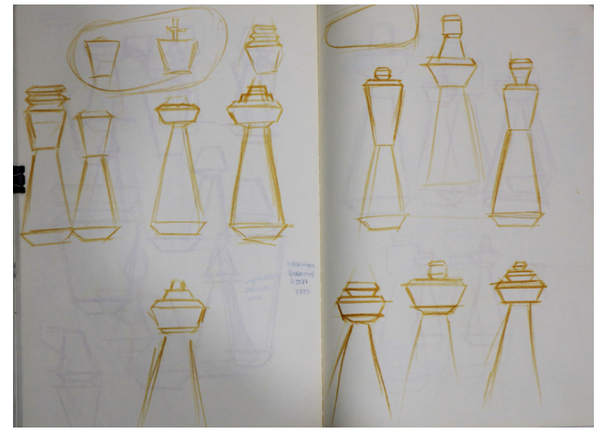


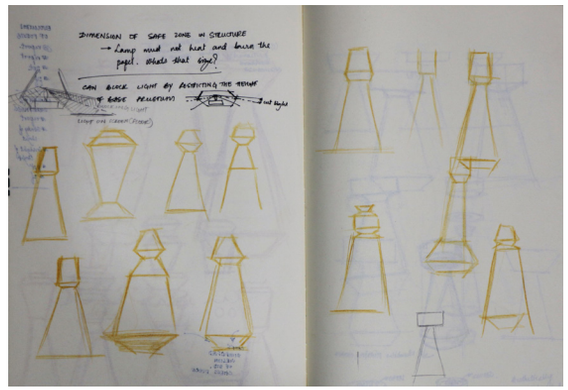


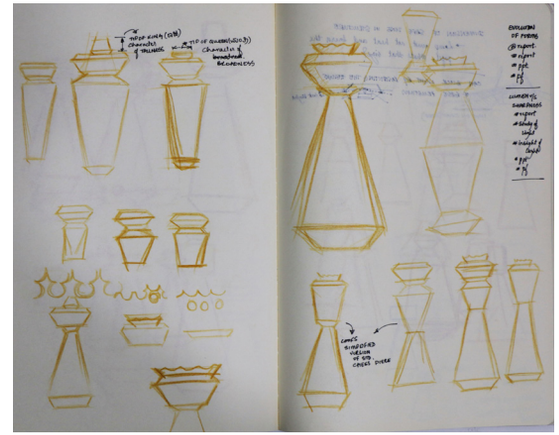




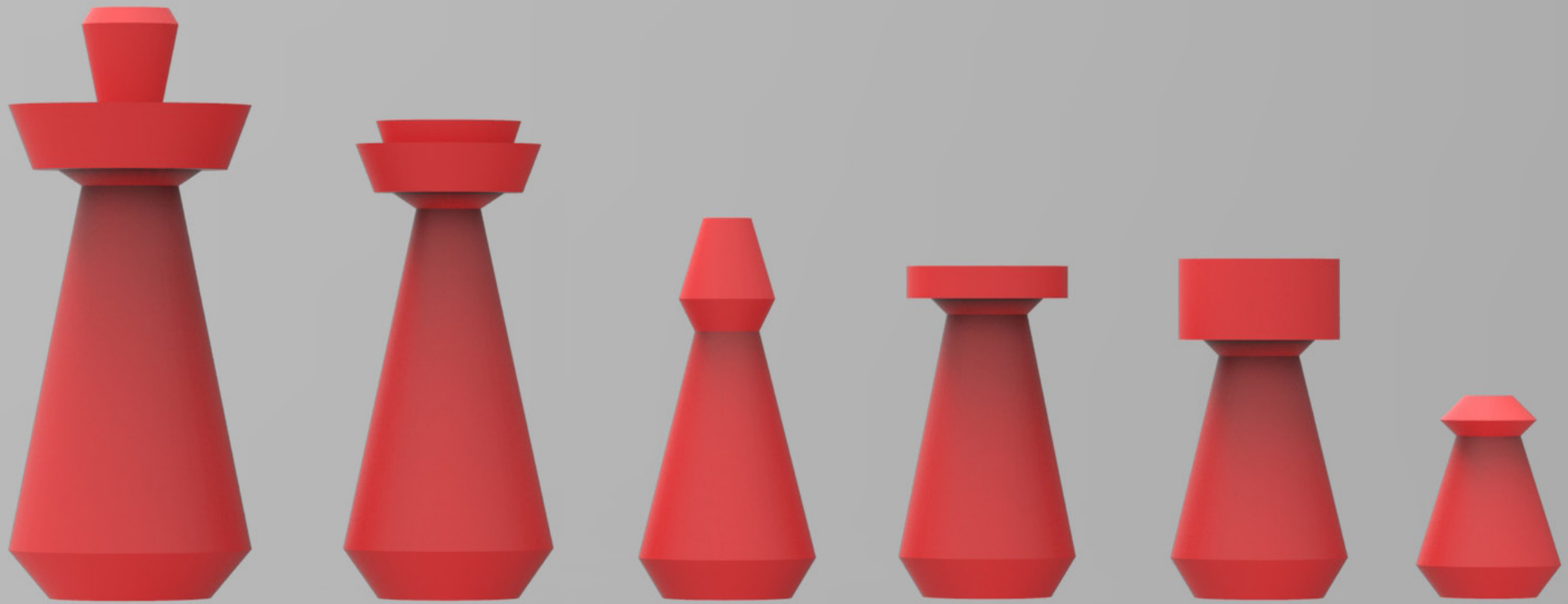








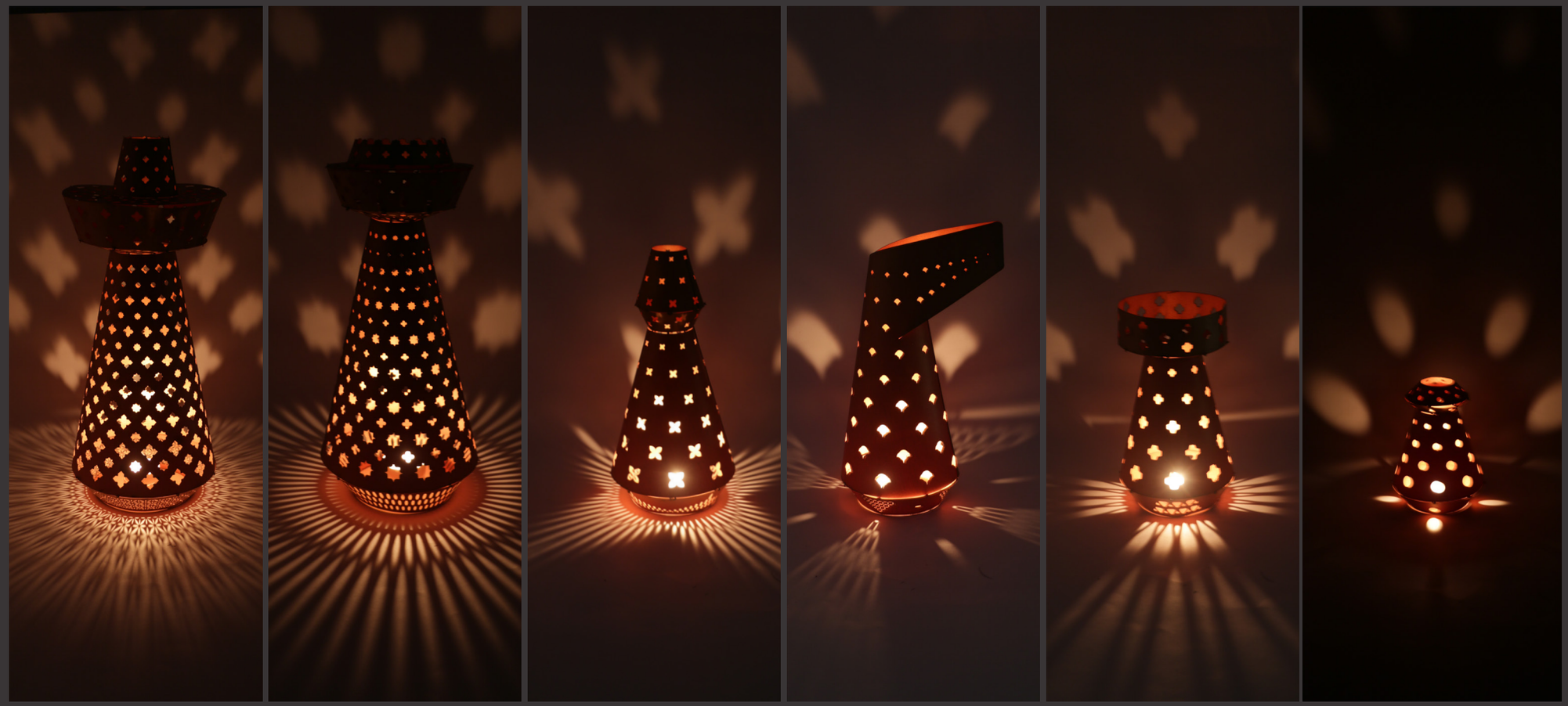
Visualising forms in CAD

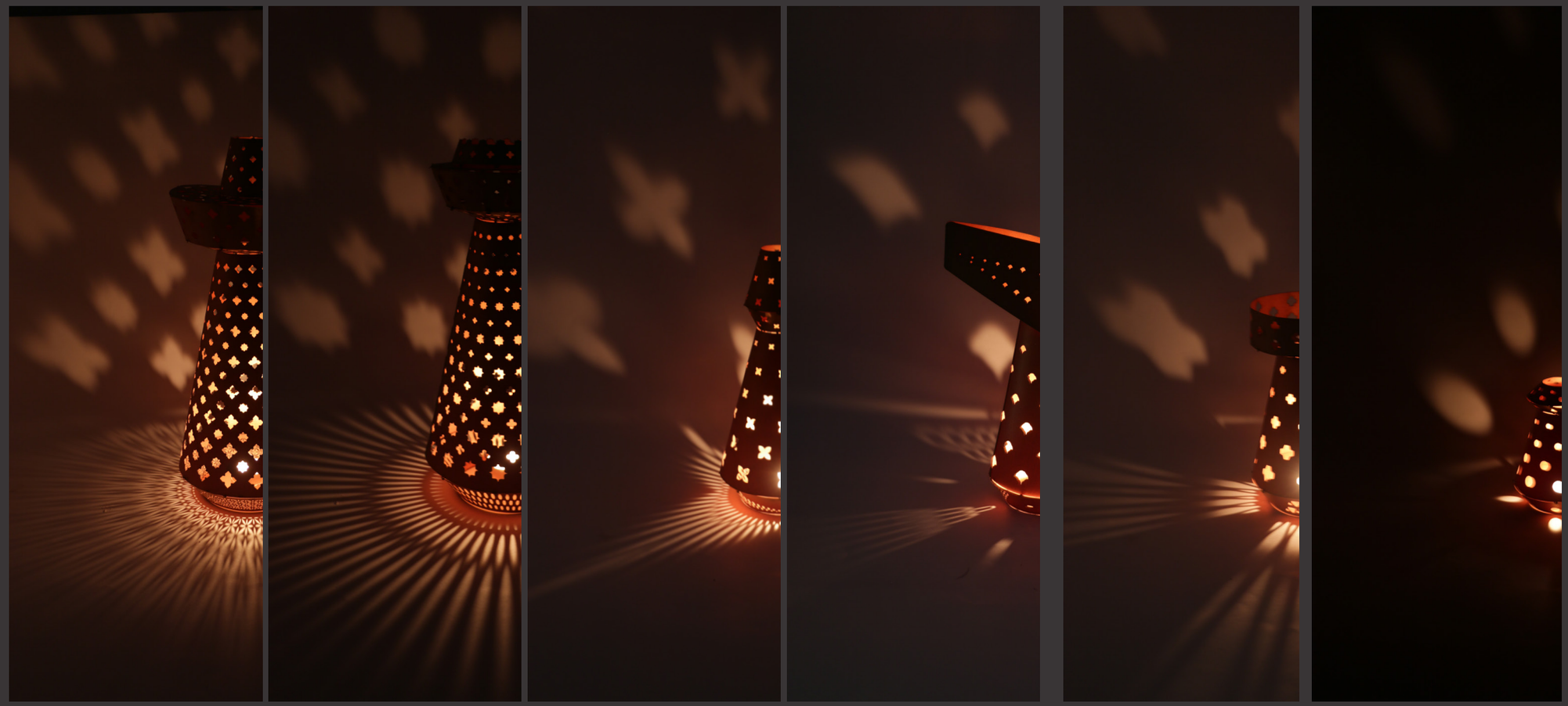


Developing paper models

Merging 3D forms with characteristic patterns

Final Design





References

- Roscoe Scott, The Evolution of the Lamp — Jan 1914 http://media.ies.org/docs/research/100papers/044.pdf
- https://www.nelt.co.jp/english/products/useful/01.html
- http://www.articlesfactory.com/articles/home-repair/the-history-of-the-lamp.html
- Lifestyle and Lighting, Thomas George, IDC IIT Bombay
- https://en.wikipedia.org/wiki/Pendant_light
- https://en.wikipedia.org/wiki/Chandelier
- https://www.homestratosphere.com/types-of-lamps-ultimate-buyers-guide/
- https://en.wikipedia.org/wiki/Sconce_(light_fixture)
- http://milkdesignshop.bigcartel.com/product/paper-lamp
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