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by

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Main Field of Study Industrial Design

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ISRN

Abstract

The project explores the harmful effects of excessive light exposure at night and people’s sleeping habits.

Most people would use electronic devices in bed for a long time before sleep, and sometimes we fall asleep and accidentally leave the light on all night. And there are also some people who are afraid of darkness prefer to sleep with the light on all night. Sleeping with the light on deliberately or unintentionally and playing electronic devices in bed are both bad sleeping habits that would lead to poor sleep quality and affect our health.

However, due to the fear of darkness, people feel safer to keep the light on when sleeping, and sometimes, we fall asleep and accidentally leave the light on; it is also hard for people to stop using electronic devices in bed. So, how can I help those people who are afraid of darkness sleep tight and avoid leaving the light on all night during sleep and how can I make people who use long-time electronic devices in bed aware of it is time to sleep?

During the research, I found that lights off can be used as a signal to remind people to sleep. The final design is a bedside lamp with a timer that can be timed through physical interaction without using apps or remote control and showing time passing intuitively.

Acknowledgements

I would like to give a special thank you to Andreas Hopf who supervised the project and gave me inspiring suggestions through the process.

Another special thank you to Claus-Christian Eckhardt.

I would also like to thank all the teachers at the division of industrial design and my classmates, who gave me a nice memory of studying in Lund.

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INTRODUCTION

The emergence of artificial light has greatly changed our life and made our life more convenient. Excessive exposure to light at night, on the other hand, will be a waste of energy and have detrimental health consequences. Sleeping with the light on or using electronic devices for a long time in bed are both bad sleeping habits that can lead to reduced sleep quality.

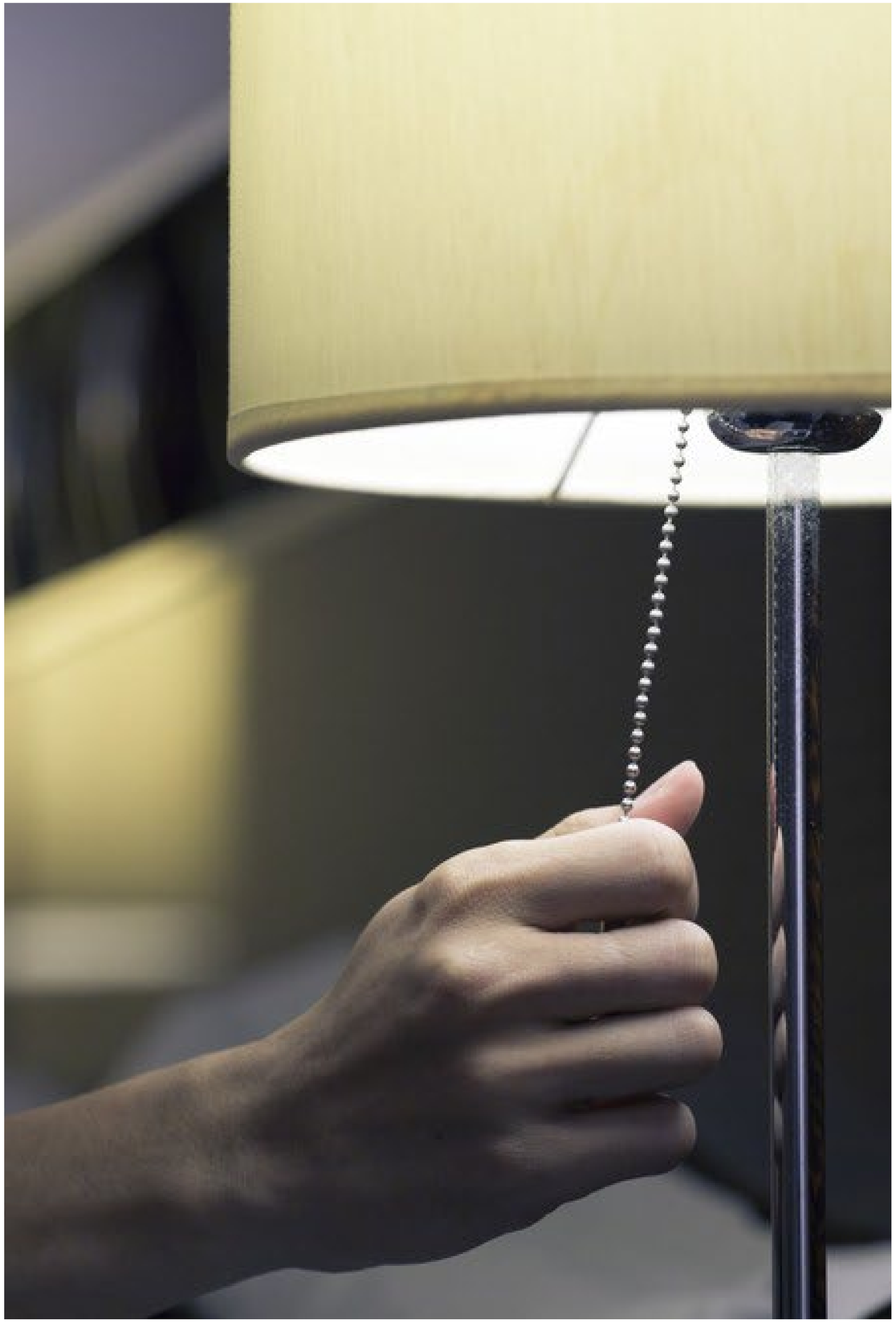
In this chapter, I looked at the harmful effects of artificial light at night in order to emphasize the significance of limiting nighttime light exposure.

INTRODUCTION
Background

Artificial light began first appeared about 250,000 years ago and electricity has allowed us to illuminate the interior of big buildings and light the night for work, recreation, and security; the advantages of this lighting are apparent and enormous (Richard G. Stevens et al., 2007).

Artificial lighting also is commonplace in bedrooms, and people with bad sleep hygiene often fall asleep with the lights on, either purposely or unconsciously (Cho, J. R. et al.,2013).

For example, we may fall asleep while reading in bed and found the light was on all night when we woke up the next day; and some people who are afraid of darkness would keep the light on during sleep.



INTRODUCTION
Background

According to a survey conducted by LED Hut, **42 percent** of British sleep with a light on, almost a quarter admit to still being scared of the dark, and **65 percent** believe it's because they're worried about intruders in their house; for those sleeping with the light on for comfort, **28 percent** admit they sleep with the bedside lamp on to feel safer (Tamara, K., 2019).

Apparently, leaving the light on all night is a waste of energy and money.

Take the UK as an example: 4.7 million people admit to leaving at least one light on before going to bed, equating to £3,619,000 spent per night during an average eight-hour period of shut-eye; the UK's night lights emit a massive 8,985,600kg of carbon dioxide per night-the equivalent of about 15 flights around the world (Utility Design, 2018).

WHILST SLEEPING

4.7 million people leave a light on when going to bed, which equates to:

- Daily average cost per user - **£0.77**
- Monthly average cost per user - **£23.42**
- Yearly average cost per user - **£281.05**
- Total money wasted in the UK per night - **£3,619,000**
- Carbon dioxide emissions per night - **8,985,600 kg**
- These emissions equate to **15** flights around the world

INTRODUCTION
Background

Light at night has two main physiological effects: it disrupts **circadian rhythms** and **suppresses the pineal gland's development of melatonin**; both human epidemiological research and animal studies have shown that nocturnal melatonin suppression can lead to **cancer** initiation and growth (Reiter, R.J. et al., 2007).

Cho, J. R., et al. (2013) studied how whole-night bedside light affects **sleep efficiency** and **brain function** and discovered that sleeping with the light on induces not only **superficial sleep** and **regular arousals**, but also has a long-term impact on **brain oscillations**, including those involved in sleep depth and stability.

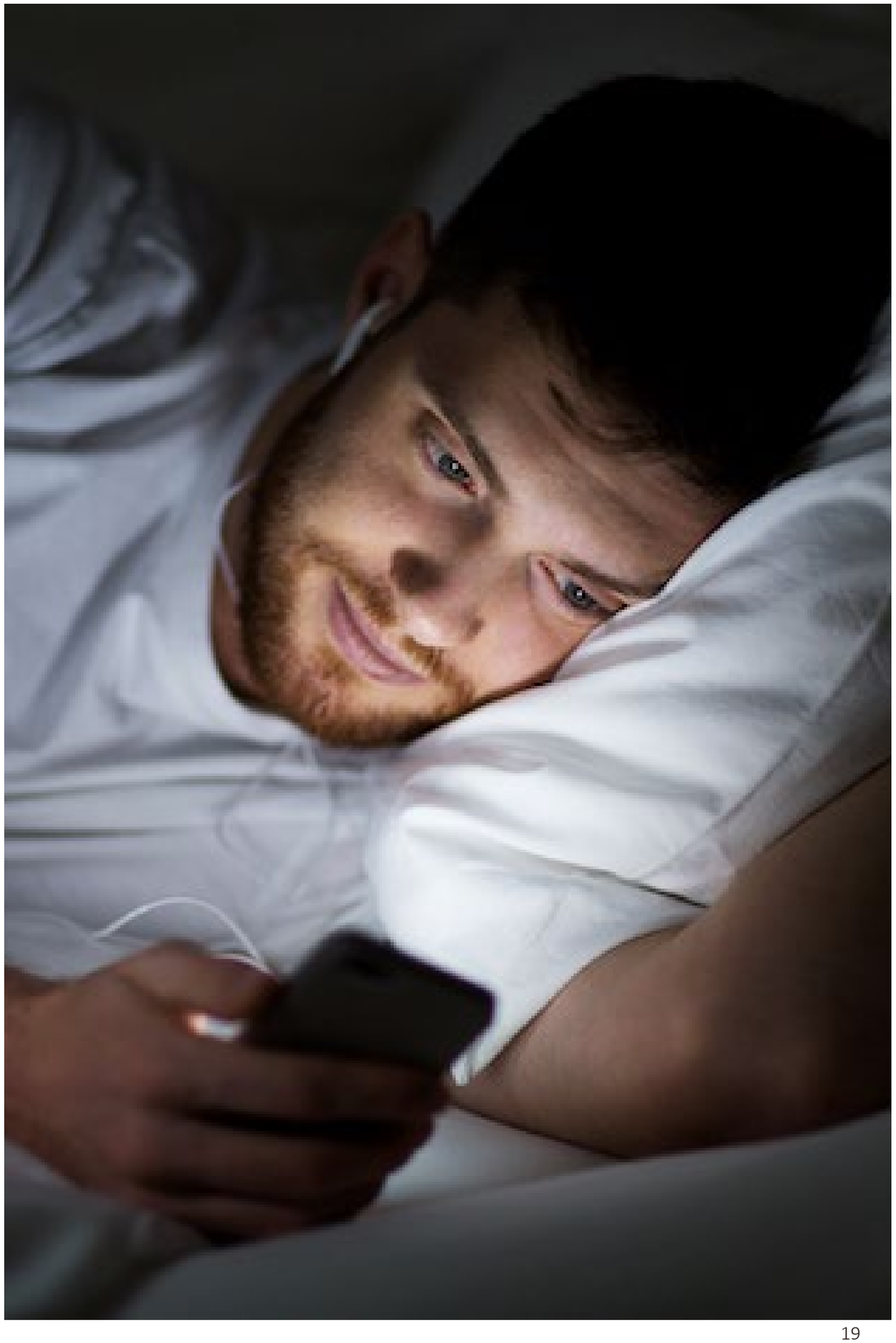
In addition, disrupting circadian and circannual cycles raises the risk of **obesity** and **metabolic syndrome**, as well as **cardiac disease**, **diabetes**, and **mood disturbances** (Cho, Y. et al., 2015).

Some people like to sleep under dim light. However, humans are highly sensitive to evening light, **even low light levels** at night when sleeping with eyes closed will **disrupt the circadian cycle** (Phillips, A. J. K. et al., 2019; Tähkämö, L. et al., 2019). **The frequency of arousals**, **the amount of superficial sleep**, and **the amount of rapid-eye-movement sleep** all rise as people are exposed to dim artificial light at night while sleeping (Cho, C.-H. et al, 2016)

INTRODUCTION
Background

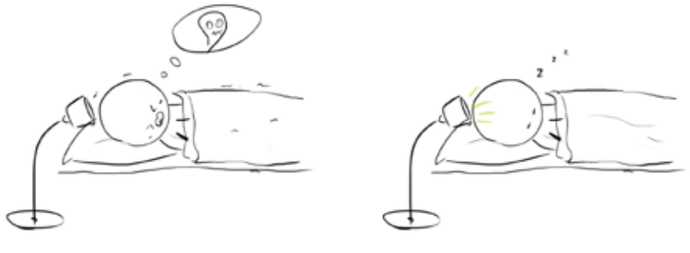
The popularity of the Internet has promoted the rapid development of electronic devices (computers, mobile phones, tablets, e-book, etc.). People use electronic devices for social networking, entertainment, reading, surfing, etc. These devices make our life much easier, but at the same time, the addiction of electronic devices affects people's sleep quality.

People are increasingly using these devices in bed for long periods of time before sleeping. The blue light emitted by these devices would increase **sleep latency**, **delay the circadian clock**, **suppress levels of the sleep-promoting hormone melatonin**, **reduces the volume and duration of rapid-eye-movement sleep**, and **reduce alertness** the following morning (Chang Anne-Marie et al., 2015).



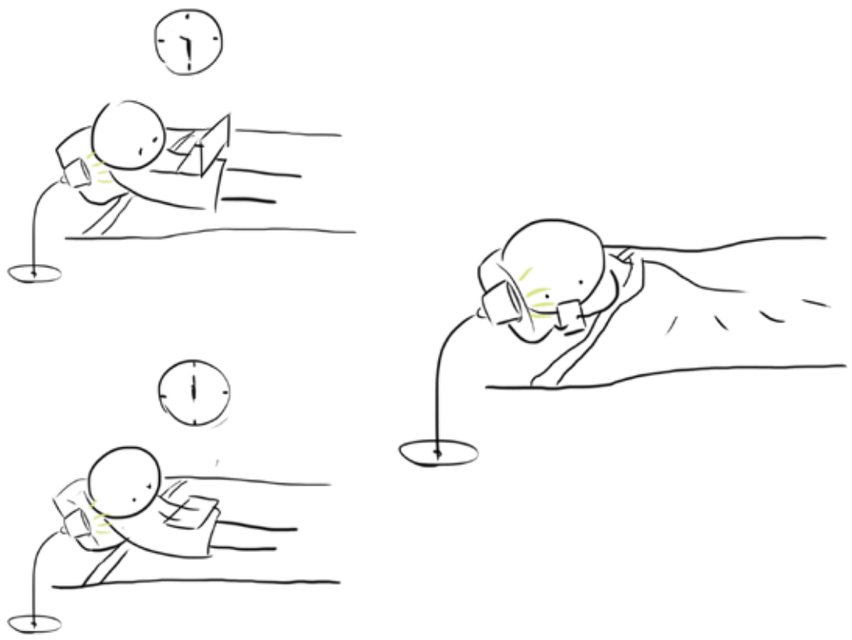
INTRODUCTION
Motivation

Sleeping with the light on deliberately or unintentionally and playing electronic devices in bed are both bad sleeping habits that would lead to poor sleep quality and affect our health. However, due to the fear of darkness, people feel safer to keep the light on when sleeping, and sometimes, we fall asleep and accidentally leave the light on all night. It is also hard for people to stop using electronic devices in bed.



So, how can I help those people who are afraid of darkness sleep tight and avoid leaving the light on all night during sleep?

and also, how can I make people who use long-time electronic devices in bed aware of it is time to sleep?



RESEARCH

This chapter included a questionnaire on people’s sleeping habits, as well as market research to compare with related products on the market, mainly to find the design direction and formulate the design brief.

RESEARCH
Questionnaire

About my personal sleeping habits, I normally get into bed an hour before sleep and then use my mobile phone or laptop during that time. When I feel sleepy, I will turn off the light, put down my phone and start sleeping. Sometimes, I will fall asleep unintentionally with the light on all night and feel not sleep well.

Turning off the light is the signal for me to sleep.

After turning off the light, I won't use my phone or laptop anymore.

A study showed that the duration of device use decreases after lights out (Walsh, N. A. et al. ,2020).

So, I'm wondering

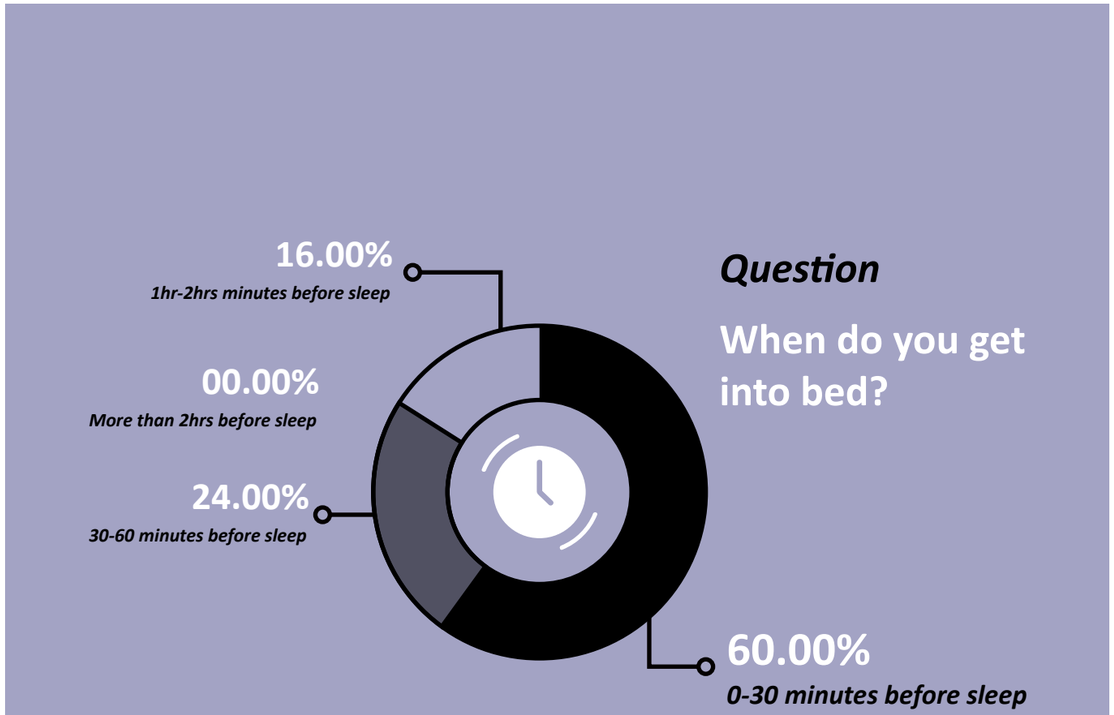
if lights off can be the signal to remind people to sleep?

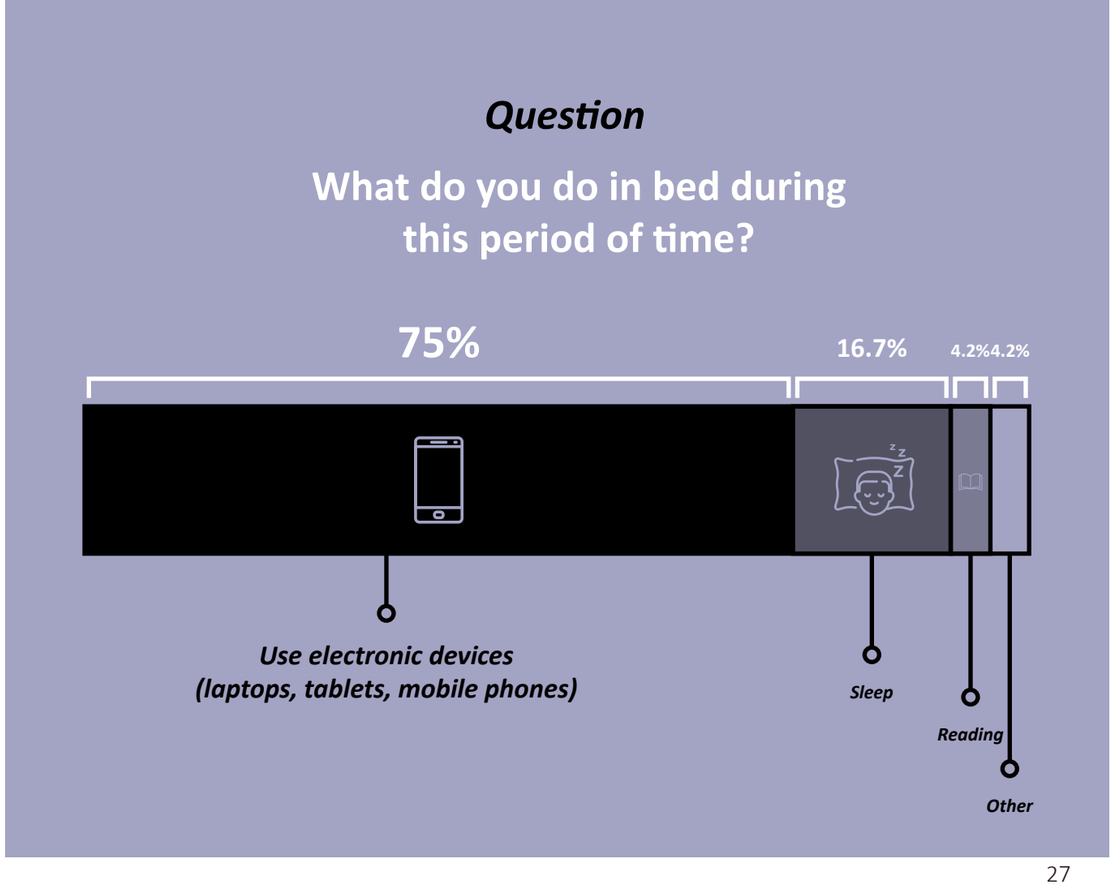
RESEARCH
Questionnaire

Then I conducted a questionnaire on people's sleeping habits to further verify whether turning off the lights can be used as a signal to remind people to sleep and explore the possible design direction.

A total of 25 people participated in the questionnaire survey. 6 questions were asked to understand the time to go to bed, the activities in bed before sleep, and the use of lights at night.

84% of the participants get into bed **between 0 and 60 minutes** before sleep. During this time, the majority of them use electronic devices.





RESEARCH
Questionnaire

In the questionnaire survey, I found that most of the participants are used to sleep with the light off. But **52%** of the participants **have the experience of accidentally falling asleep with the lights on all night**.

60% of the participants **turn off the light when they close their eyes to sleep**, while 40% of them turn off the light as soon as they get into bed but don't intend to fall asleep immediately.

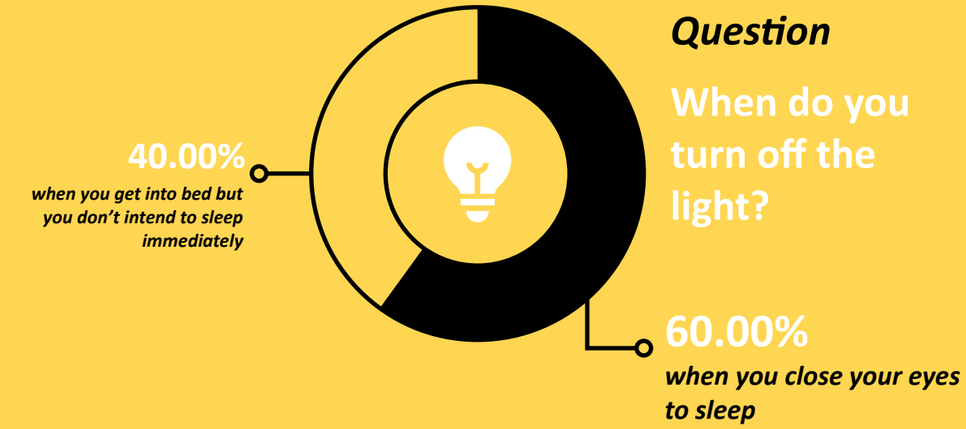
I also paid attention to people's behavior after turning off the lights, and found that after turning off the lights,

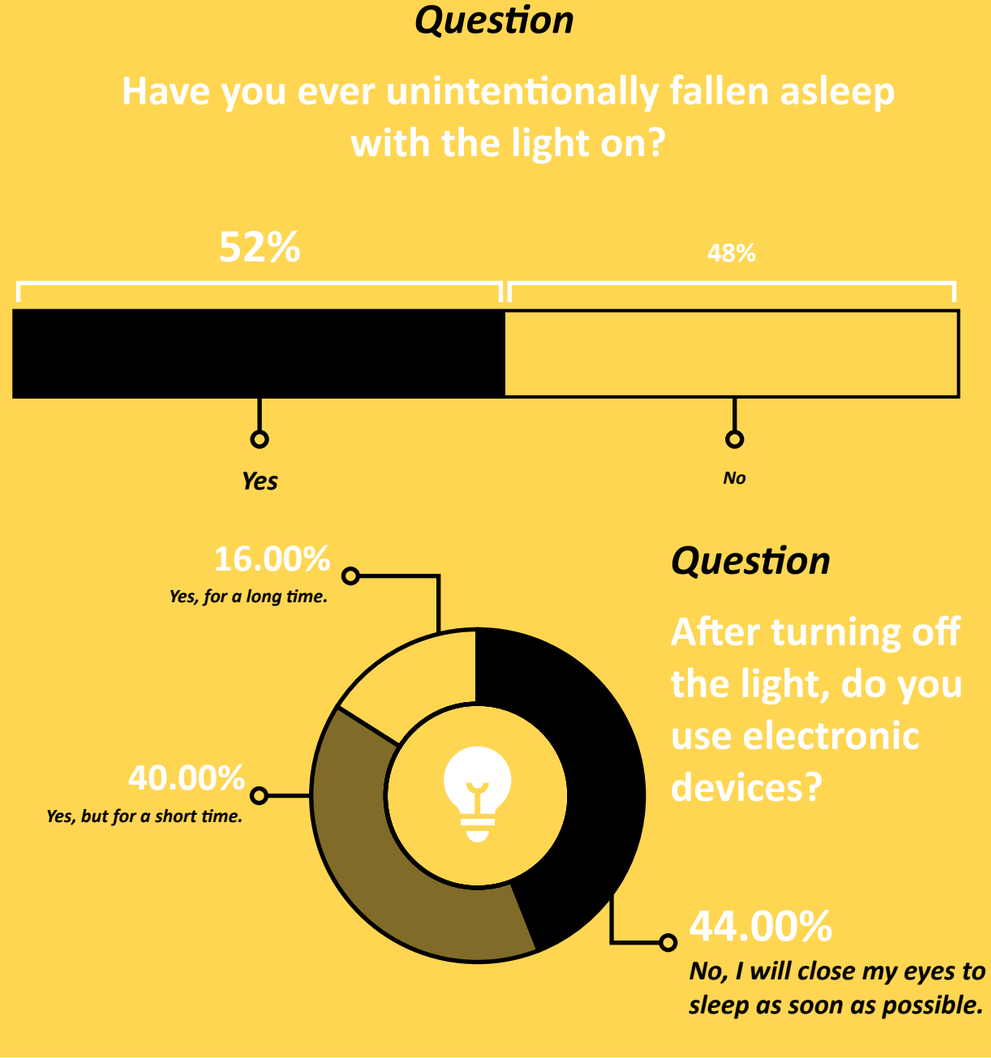
only **16%** of the participants continue to use electronic devices for a long time,

84% of people either close their eyes to sleep as soon as possible or use electronic devices just for a short time, **which means that after turning off the light, people will limit the amount of time of using electronic devices and have the intention to sleep.**

This also confirms that

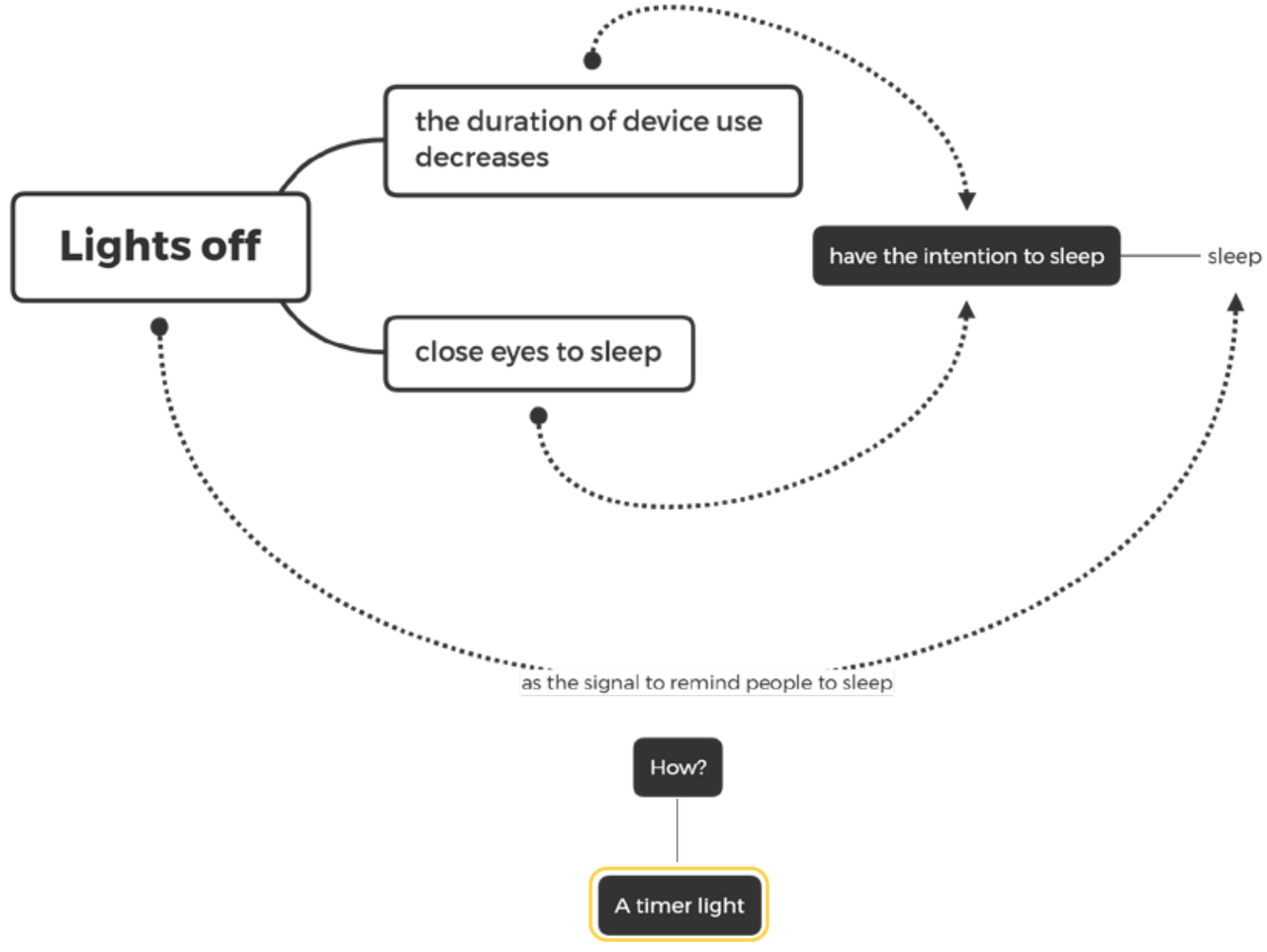
Lights off can be used as a signal to remind people to sleep.





Lights off can be used as a signal to remind people to sleep, but what can I do and how can I use the signal?

Then I think it would be more feasible to incorporate a timer to switch the light off.



Design Brief

Design a bedside lamp with a timer

as a signal to remind people to sleep
to help people who unintentionally fall asleep with the light on
to save electricity
...

RESEARCH
Market research

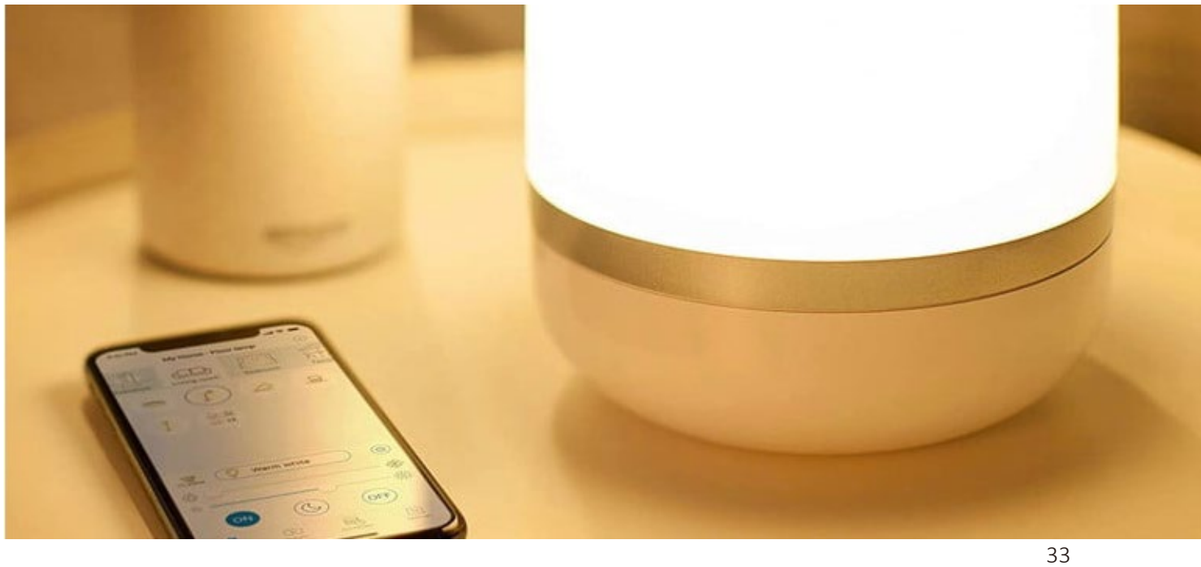
Of course, the timer lamp is not a brand-new concept. There are already various timer lamps on the market.

However, most of the timer lights on the market now are using remote control or smartphones to set the timer.

In addition, various smart products have appeared on the market, including smart lights, or home smart assistants. Users can set the timer by pressing the electronic button or by voice control.

However, **using the remote control or smartphone or app for light timing will make the interaction more complicated**.

After the user sets the timer, these products **do not have intuitive feedback to reflect the passage of time**.



RESEARCH
Inspiration

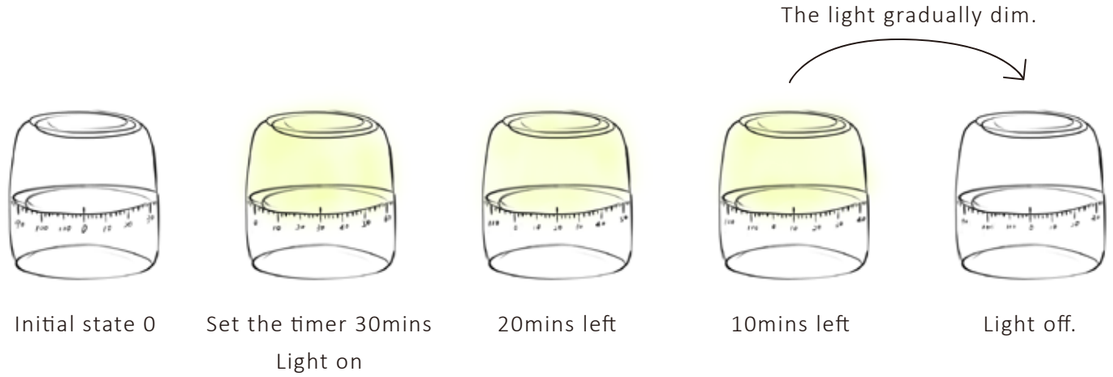
The mechanical timer is commonly used in the kitchen. The angle of rotation determines the set time. After setting the time, we can clearly feel the passage of time.

When studying, I often use Pomodoro to improve work efficiency. The feedback of showing the passage of time intuitively allows me to focus on my study to improve procrastination and have better time management.

Inspired by the kitchen timer and Pomodoro, it would be better to show the time passing intuitively (feedback), which can better make people aware of the situation.

Feedback is one of Norman's design principles, in design, it is important to show the effect of an action; without feedback, one is always wondering whether anything has happened (Norman, D.A., 2002). For example, if the product show the time passing intuitively, the user would know the product is working and they can know how long time has passed.

Without using app or remote control to set the timer, use physical interaction to make people think and set the time carefully, thus making them have better time management before sleep.



Timer setting
Show the time passing intuitively
without app or remote control

Better time management
Improve procrastination
Remind people to sleep

Final Design Brief

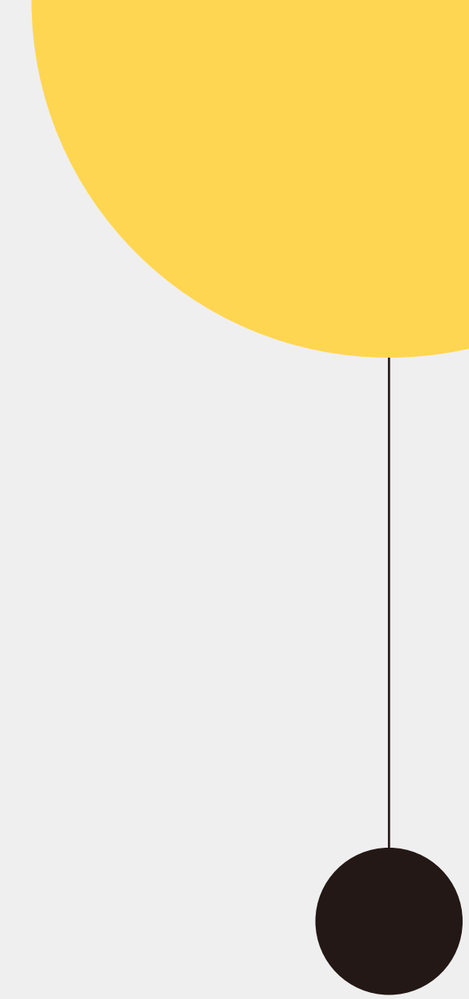
Design a bedside lamp with a timer that can be timed through physical interaction without using apps or remote control and showing time passing intuitively.

→

to make people aware of the situation
as a signal to remind people to sleep
to help people who unintentionally fall asleep with the light on
to save electricity
to accompany people who are afraid of turning off the light when sleeping
to make people set time carefully
to help people have a better time management
...

CONCEPT DEVELOPMENT

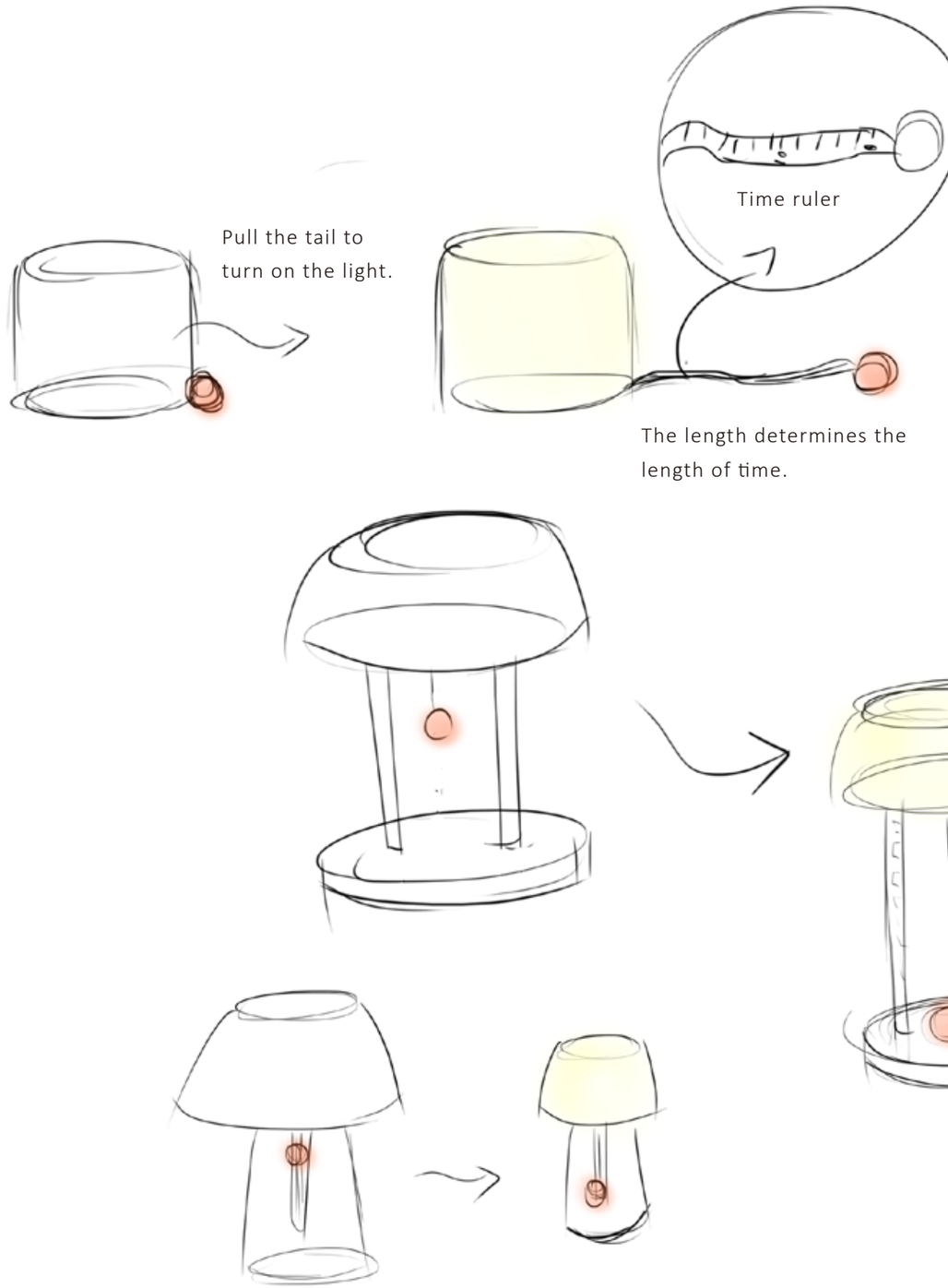
Based on the final design brief, I started to enter the design phase. This chapter shows my design process, including ideations, structure research, structure testing, mock-ups making, etc.

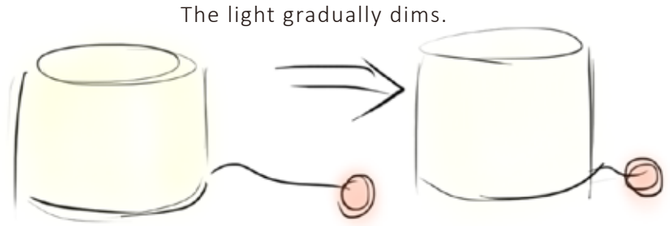


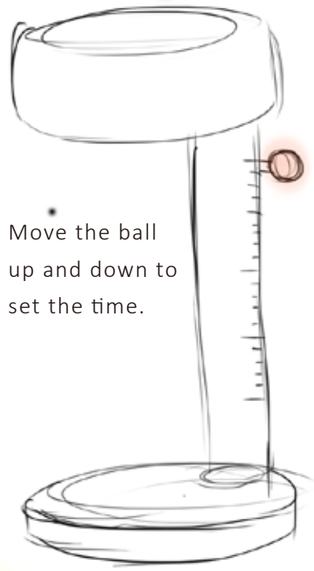
CONCEPT DEVELOPMENT

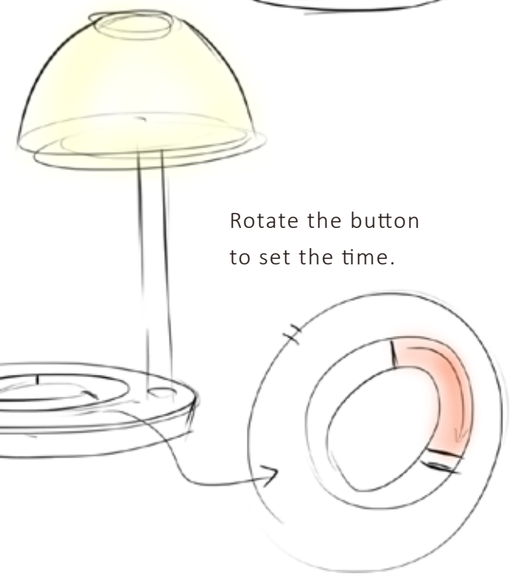
Ideation stage 1

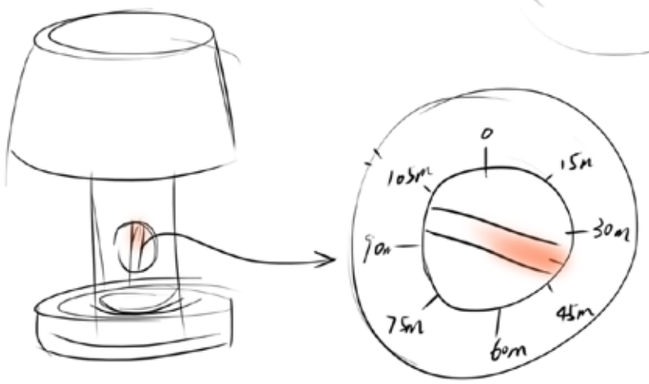
Ways of showing the time passing intuitively











CONCEPT DEVELOPMENT

Structure research of the kitchen timer

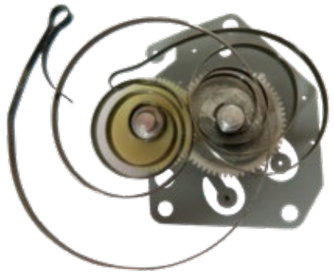
The mechanical kitchen timer was invented in 1926 and is still commonly used today.

The use of this traditional form of the kitchen timer is very simple. You only need to turn the lower part where the pointer is to set the time, and then as time goes by, the pointer will gradually return to zero.

It uses the original mechanical structure to show the time passing intuitively. A similar structure can be used in the subsequent design. To better understand this structure, I disassembled the kitchen timer.

CONCEPT DEVELOPMENT

Structure research of the kitchen timer



Mechanical kitchen timers use clockwork to measure time, which includes gears, springs, an escapement and a pendulum or a balance wheel. These parts work together to ensure the proper operation of the timer.

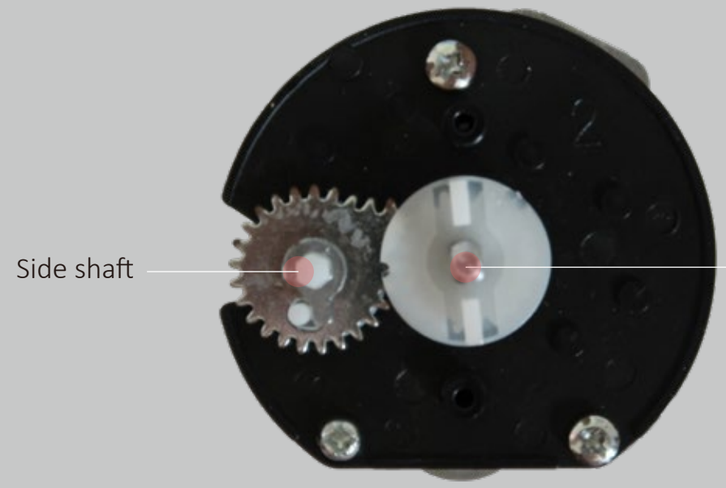
The main shaft is connected with the mainspring and a dial. The side shaft is connected with the alarm structure.

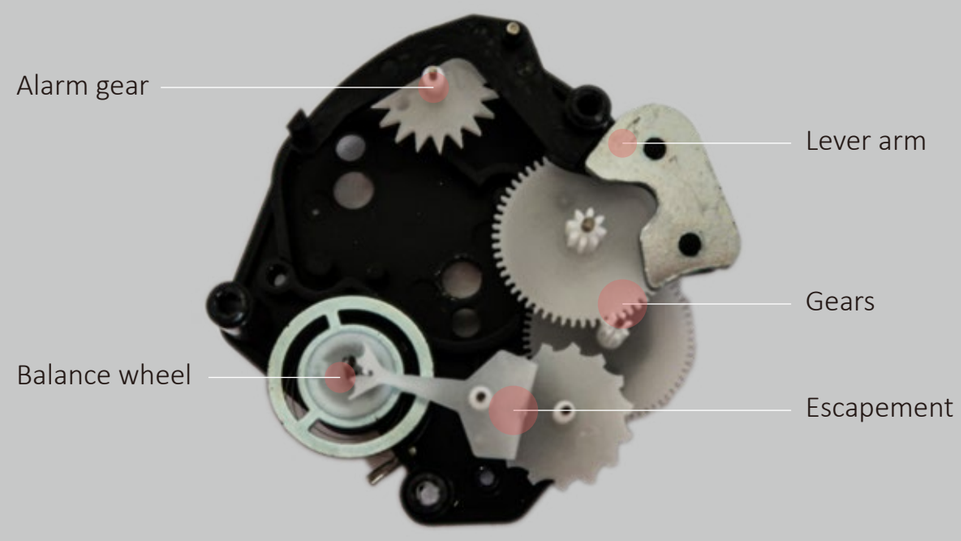
Manual timers are typically set by turning a dial to the time interval desired; turning the dial stores energy in a mainspring to run the mechanism.

The energy in the mainspring causes a balance wheel to rotate back and forth. Each swing of the wheel releases the gear train to move forward by a small fixed amount, causing the dial to move steadily backward until it reaches zero when a lever arm strikes a bell.

The escapement controls the speed at which the spring within a mechanical timer unwinds. In doing so, the escapement ensures that a unit stays in sync with time. Basically, an escapement constitutes a type of catch. This catch catches, or stops, the teeth of the gears of a mechanical timer, then releases them. This catch-and-release cycle creates a rhythm that keeps a mechanical timer in sync with the passing of time, allowing a unit to accurately keep track of time.

One of two devices controls the rhythm of the catch-and-release cycle of an escapement in a mechanical timer, a pendulum or a balance wheel. A pendulum swings back and forth at a rate determined by its length and the weight at its bottom. A balance wheel turns one direction then the other, back and forth, in a continuous cycle, with force provided by a tiny spring. The timing of the pendulum or balance wheel controls the length of time an escapement catches the teeth of a timer gears, determining a timer's ability to accurately keep time.





CONCEPT DEVELOPMENT

Structure research of the pull-string toy

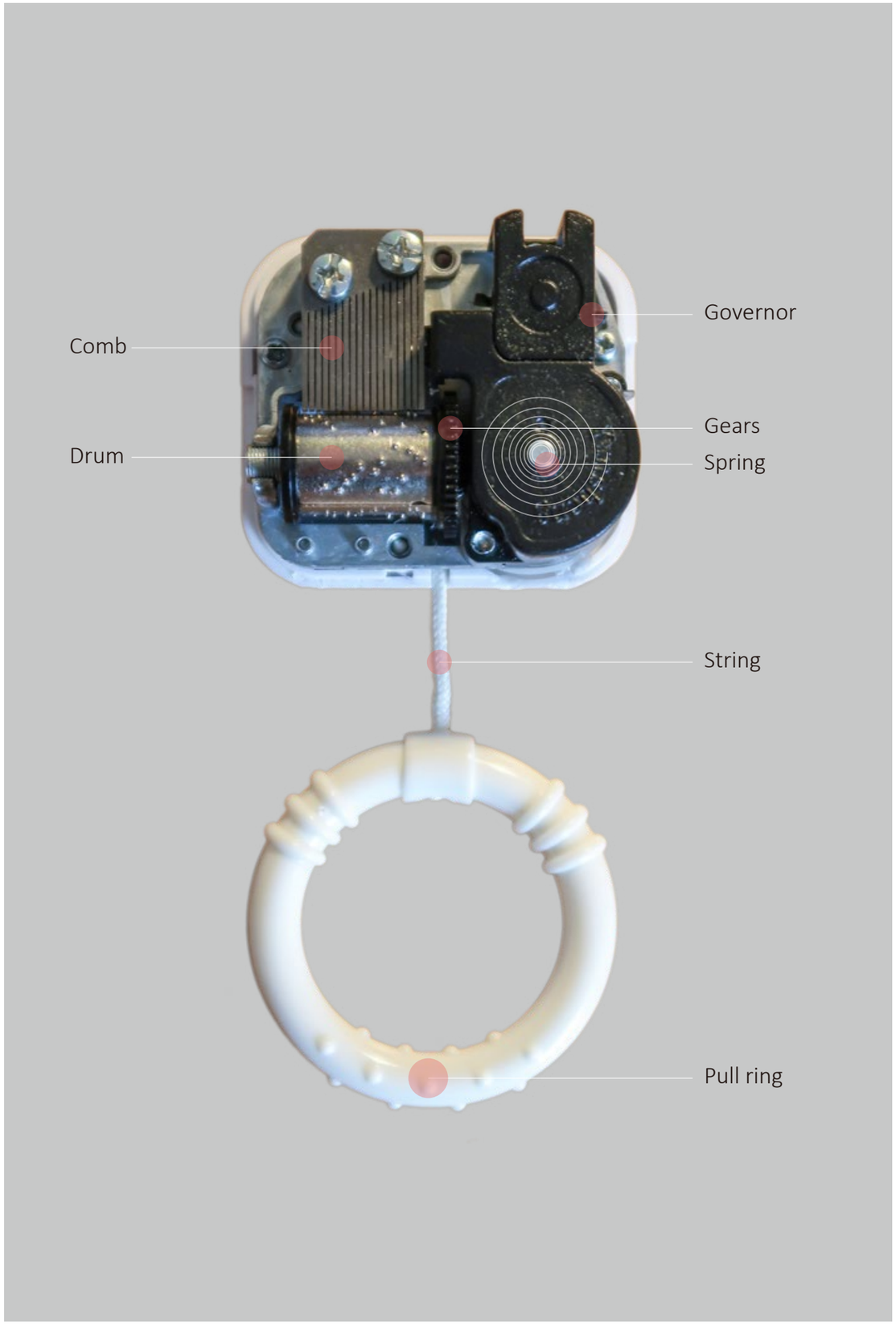
I remembered the mechanical toy I used to play with as a child. It may be a car with a cord attached to it. When I pulled the string and let it go, the car would run away. When the string was retracted, the car would stop.

Similar toys include pull-string music boxes, pull-string talking dolls, pull-string-dancing toys. The mechanical structure used in these toys is clockwork.

Then I bought a pull-string music box and disassembled it to better understand how it works.

The spring inside is connected to a shaft which is attached to the structure of winding string. Pulling the string stores energy in the spring. As the spring unwinds, it rotates the gears and then drives the music box.

The governor is connected to the drum by a gear train. The governor uses air resistance to control the release of energy from the spring to control the speed. The drum will stop when the governor stops.



CONCEPT DEVELOPMENT

Structure research of the mechanical timer

The mechanical timer also uses the structure of clockwork.

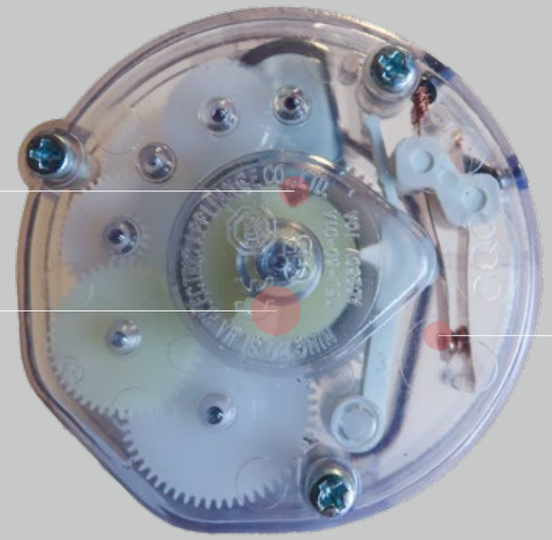
The mainspring is the power source of the timer. The mainspring has one end attached to the main shaft and the other end bound to the gear.

Rotate the knob on the chronograph to wind the mainspring. The energy in the mainspring drives the gears to rotate. The rotation of the gears drives the cam to work.

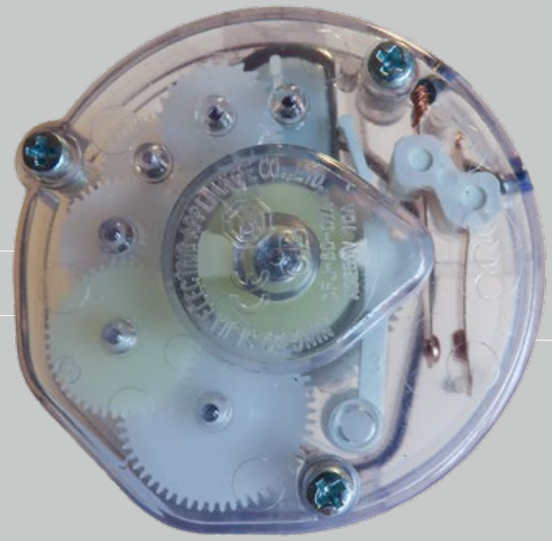
When the cam's arc touches the contact's reed, the upper reed is forced to bend down, closing the contact and turning on the power; when the cam's notch aligns with the contact's reed, the upper reed bounces upwards to separate the contacts, cutting off the power, and realizing timing control.

This structure can be used in the subsequent design to realize the timing function and show the time passing intuitively.

Power On



Power Off



CONCEPT DEVELOPMENT

Tick-tacking sound of the mechanical timer

During the research, I found this traditional timer will make a tick-tacking sound after timing, and the ticking sound will stop when the timing time is reached.

The tick-tacking sound can also been integrated as an activity to fall asleep and remind people of the passage of the time. Certain constant sounds are not disturbing sometimes, also makes you sleep.

On average, 10% of the population can't get enough of the sound of a ticking clock. This is most likely due to the soothing effect that a metronome-like sound may have. The repeated, rhythmic pattern may aid in the creation of order, resulting in feelings of calm and calm inside ourselves (Bootshearingcare, n.d.).

Interaction

① pull the string

ball

ring

triangle

cylinder

fish ?

② dial

Old Telephone

Connection

Separate ?

Time Perception

Reference

Without Reference

Type

Table Lamp

Floor Lamp

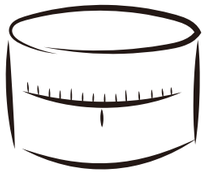
Wall Lamp

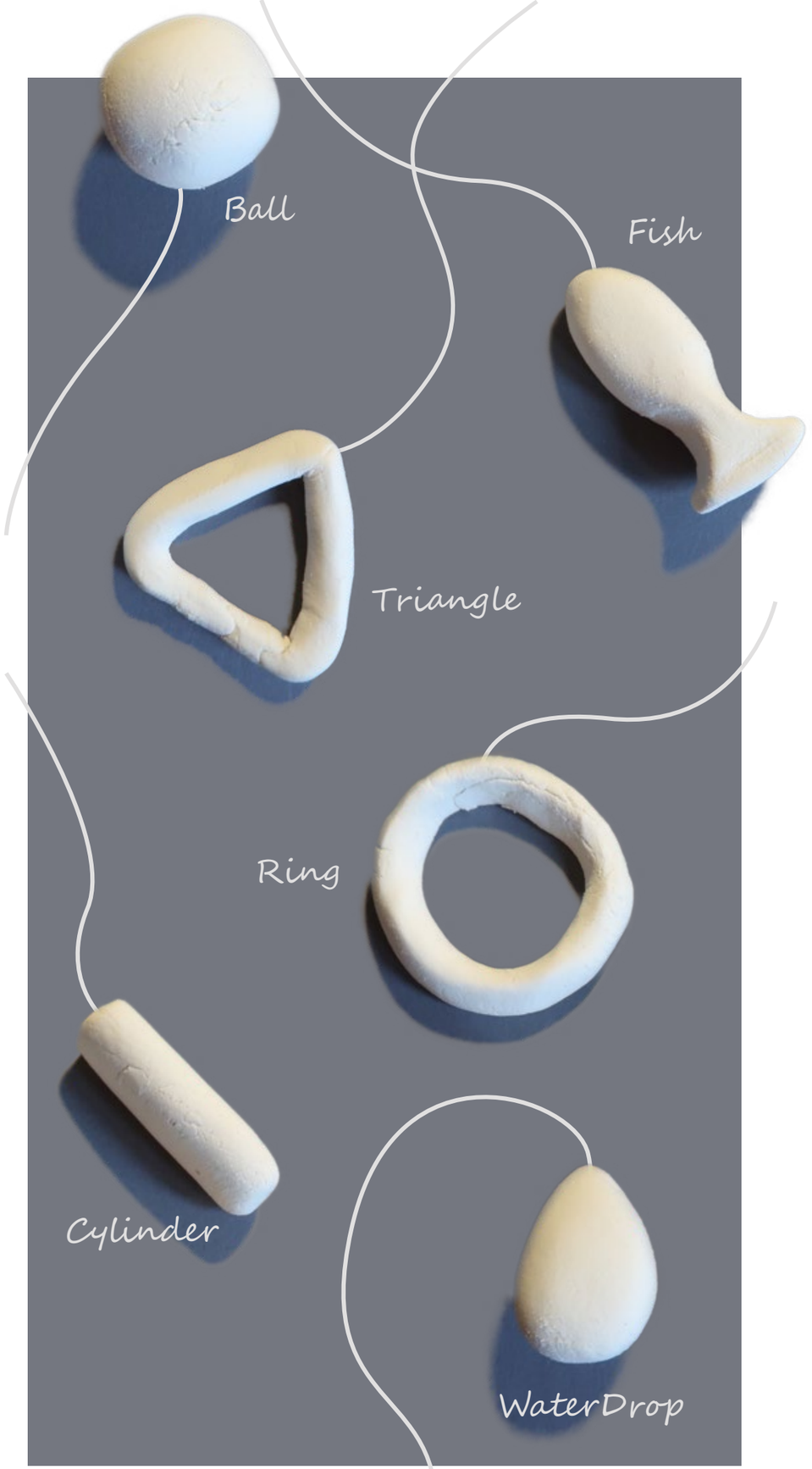
CONCEPT DEVELOPMENT

Ways of interaction

Based on the above structure research, I began to explore the interesting interaction modes that the light may have.

Inspired by the kitchen timer and the mechanism toy, I thought of two possible ways of interaction. One is by pulling the string and the other is by turning the dial.



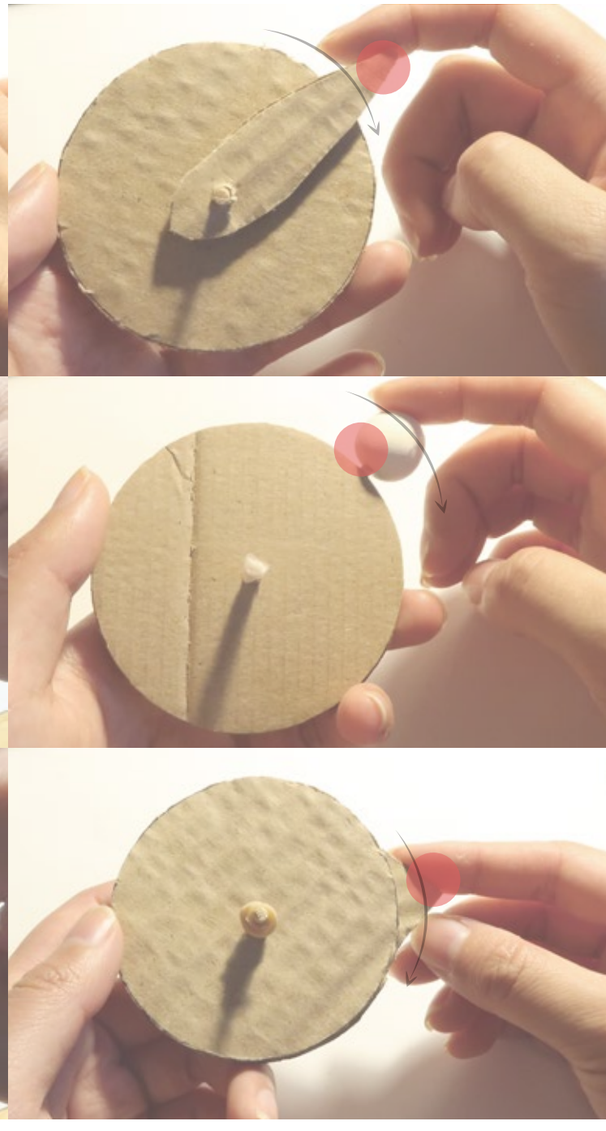


CONCEPT DEVELOPMENT

Ways of interaction

I made some sketch models to explore different ways of interaction.

It can be the dial of the antique telephone which can bring back memories, or it can be...



CONCEPT DEVELOPMENT

Maximum set time

The maximum set time of current mechanical timers is generally 15 minutes, 30 minutes, 60 minutes, and 120 minutes.

The normal time it takes most people to fall asleep at night is between 10 and 20 minutes. One study found that your sleep quality will decrease if it takes you longer than a half hour to fall asleep.

Some people have the habit of reading books before sleep. Reading for 30 minutes is associated with lower blood pressure and heart rate and significant reductions in stress. On average, the pre-sleep readers spent about 43 minutes reading in bed.

According to the questionnaire before, most of the participants get into bed one hour before sleep.

So, **60 minutes** may be the most suitable maximum set time.

How long is

the maximum set time?

30 minutes?

60 minutes?

120 minutes?

...

CONCEPT DEVELOPMENT

Ideation stage 2

Pull the string- *without reference*

Use red ball, like the clown's nose

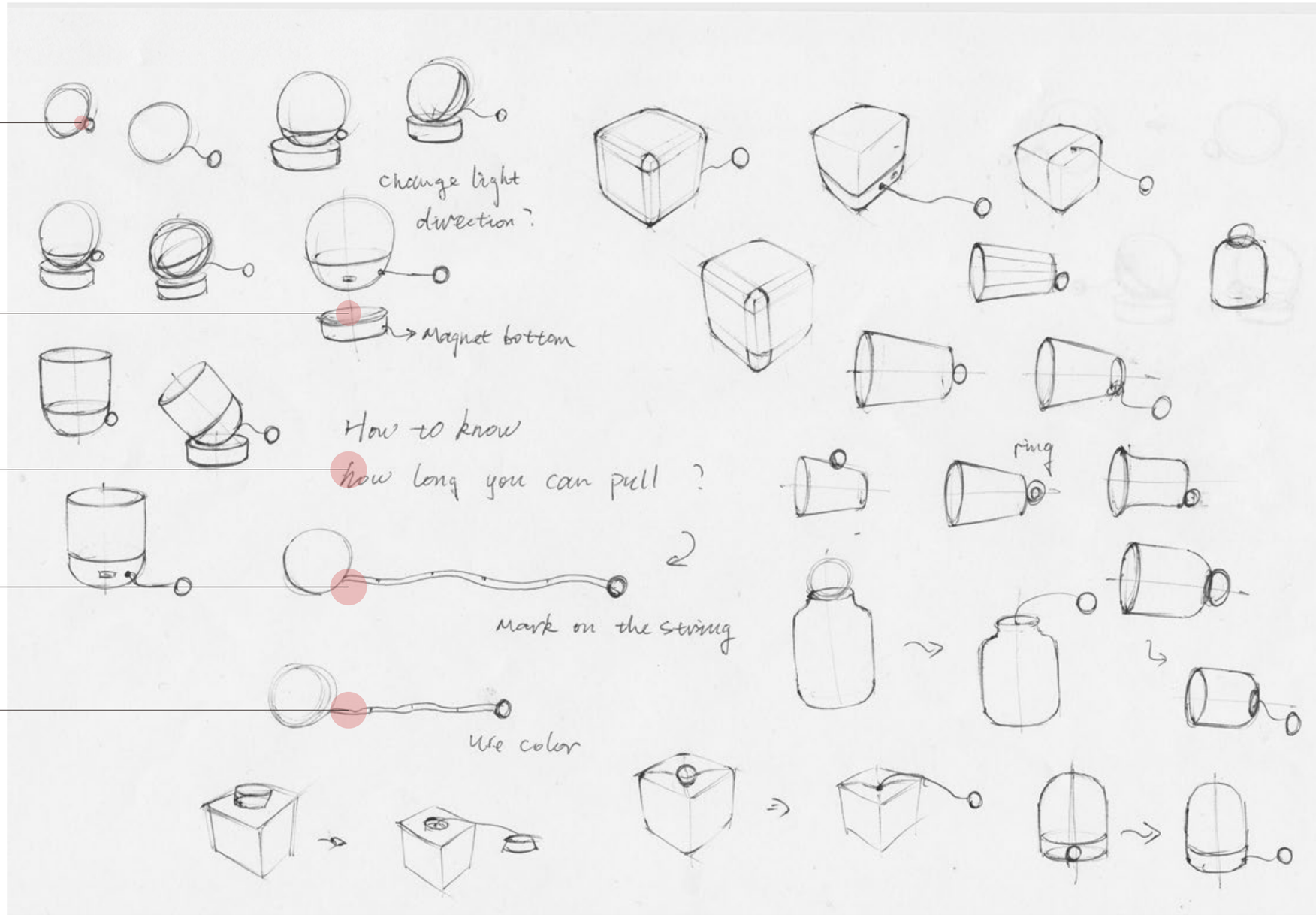
Use magnet bottom to adjust the light direction

How can users know how long they can pull?

1. Make small marks on the string.

2. Use colors (different colors or gradient colors)

 # Simple
 # Playful
 # Not easy-going



CONCEPT DEVELOPMENT

Ideation stage 2

Pull the string- *with reference*

Pull the string within this range

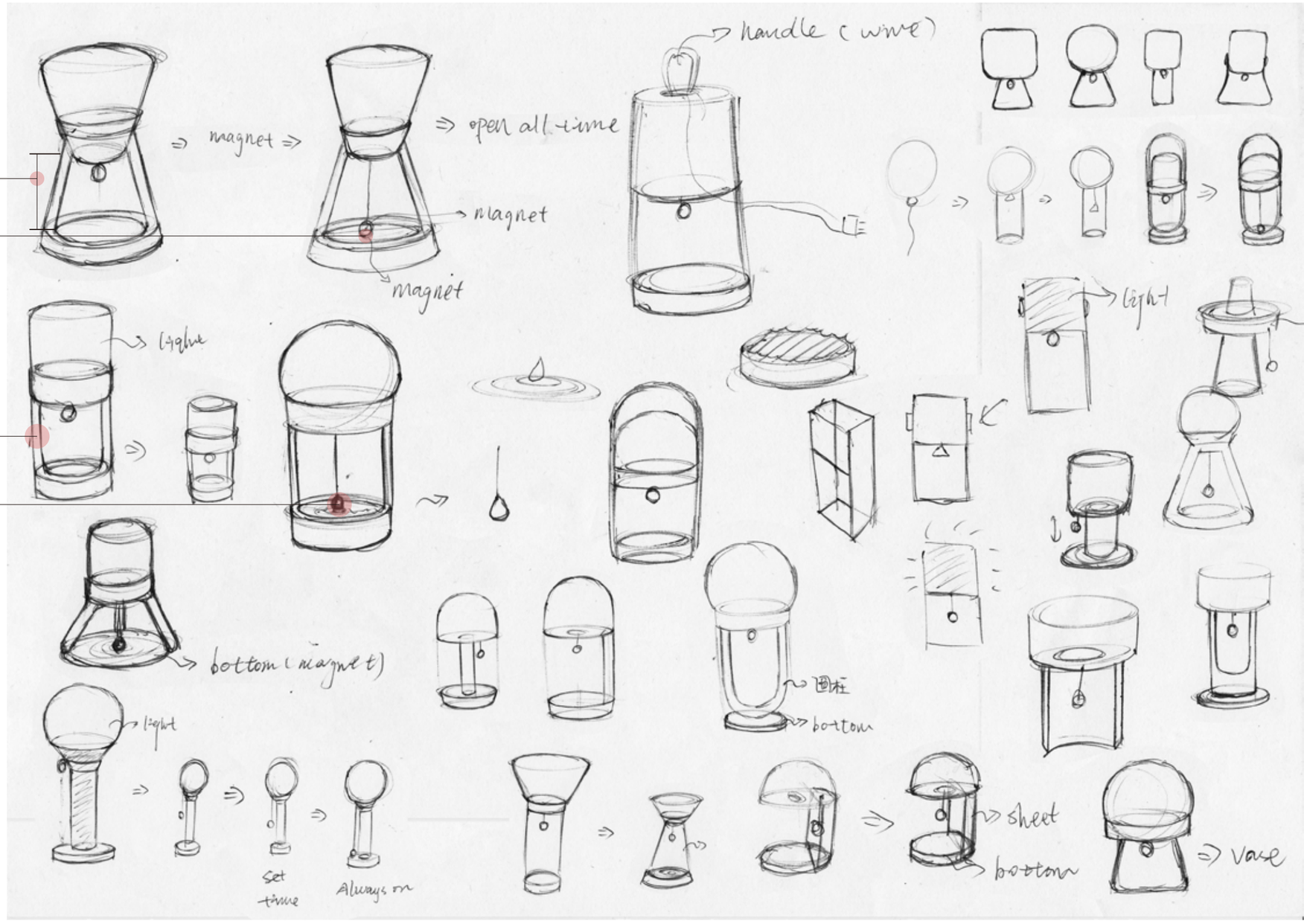
Use a magnet to hold the ball to keep the light on (whether is it necessary to keep the light on?)

Need to test whether the magnetic force can hold the ball

With support, it will be more stable when pulling the string vertically

Add textures to the bottom

Water ripple



 # Simple
 # Playful
 # Easy-going

CONCEPT DEVELOPMENT

Ideation stage 2

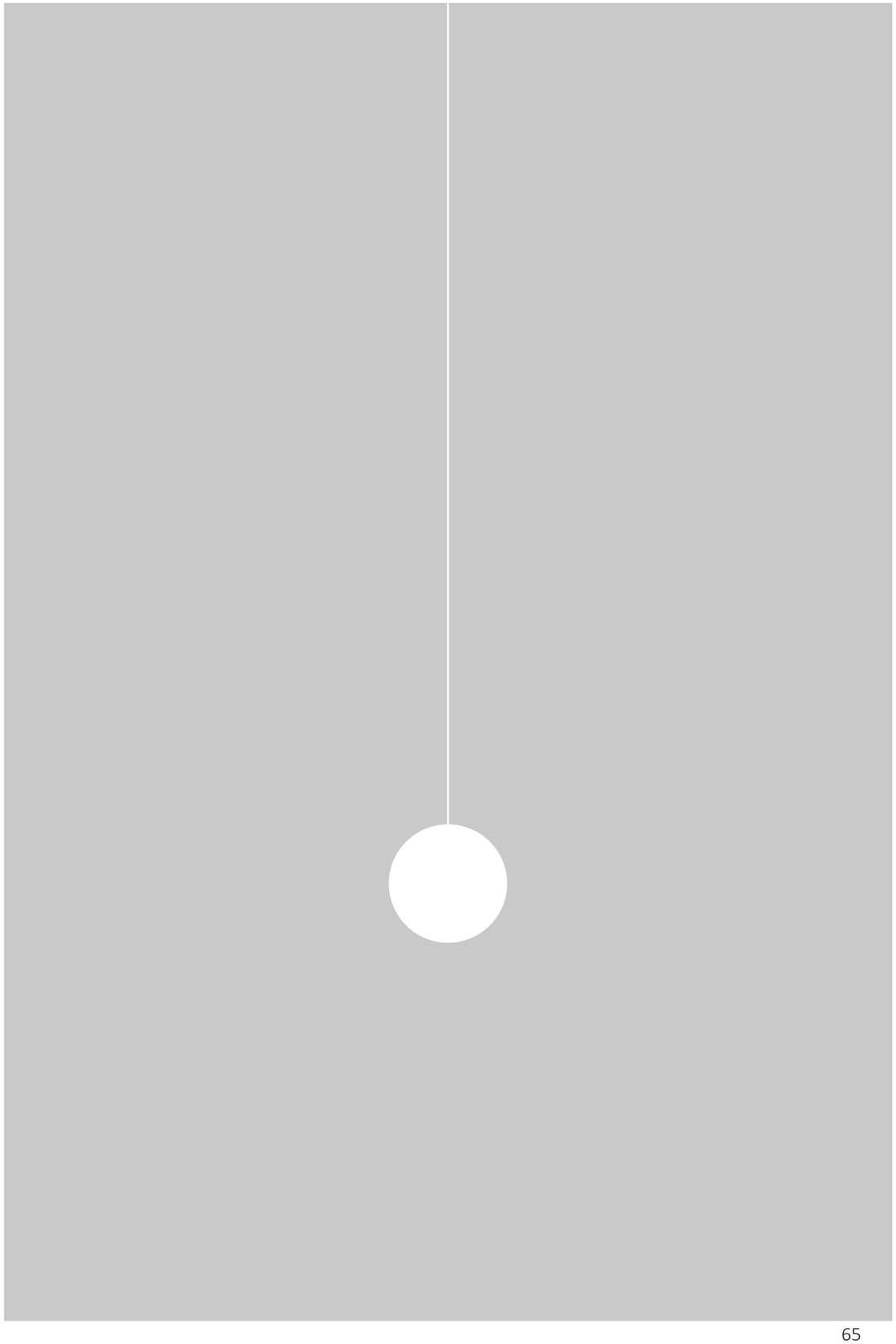
Problems of pull-the-string interaction

The length of the string determines the time. However, the user cannot retract the string to shorten the time,

add a knob to retract the string or add another switch?
or leave it alone? since 60-minute time is not too long.

After the user set the timer, the light won't go off until the string is retracted. How can the user turn off the light during the set time?

add another switch?
or leave it alone?- since 60-minute time is not too long, which can urge users to set the timer carefully, have good time management, cherish time.....



CONCEPT DEVELOPMENT

Ideation stage 2

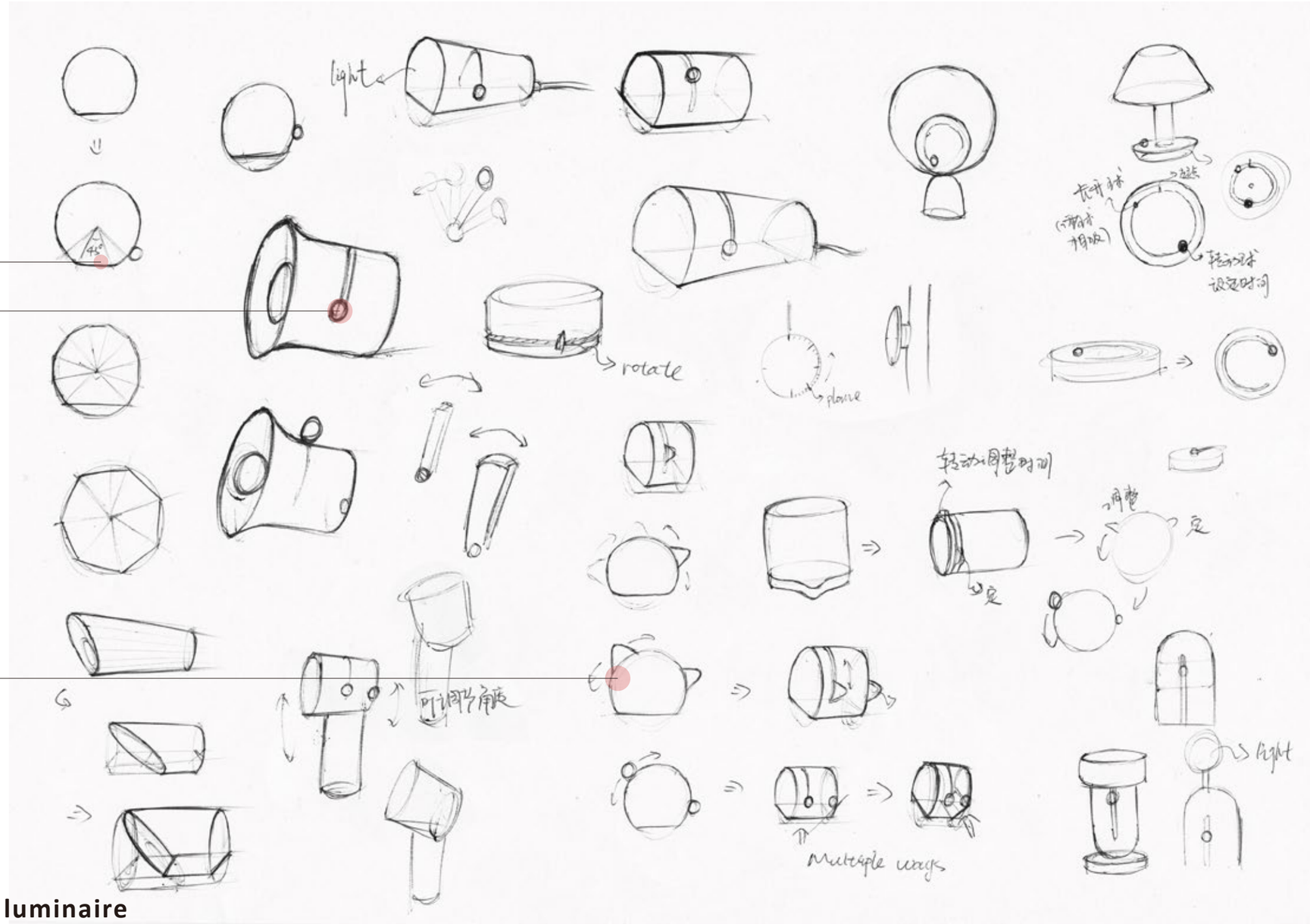
Turn the dial

Flat bottom- can be placed stably

Dial the ball to set the timer

The ball can be dialed back and forth to set the time flexibly. Turn on and off the light by dialing the ball.

One is fixed on the lamp and can be used as the reference, the other one can be dialed to adjust the time.



 # Simple

 # Not easy-going

 # Wrong light direction for bedside luminaire

CONCEPT DEVELOPMENT

Ideation stage 2

Or a floor lamp?

CONCEPT DEVELOPMENT

Ideation stage 2

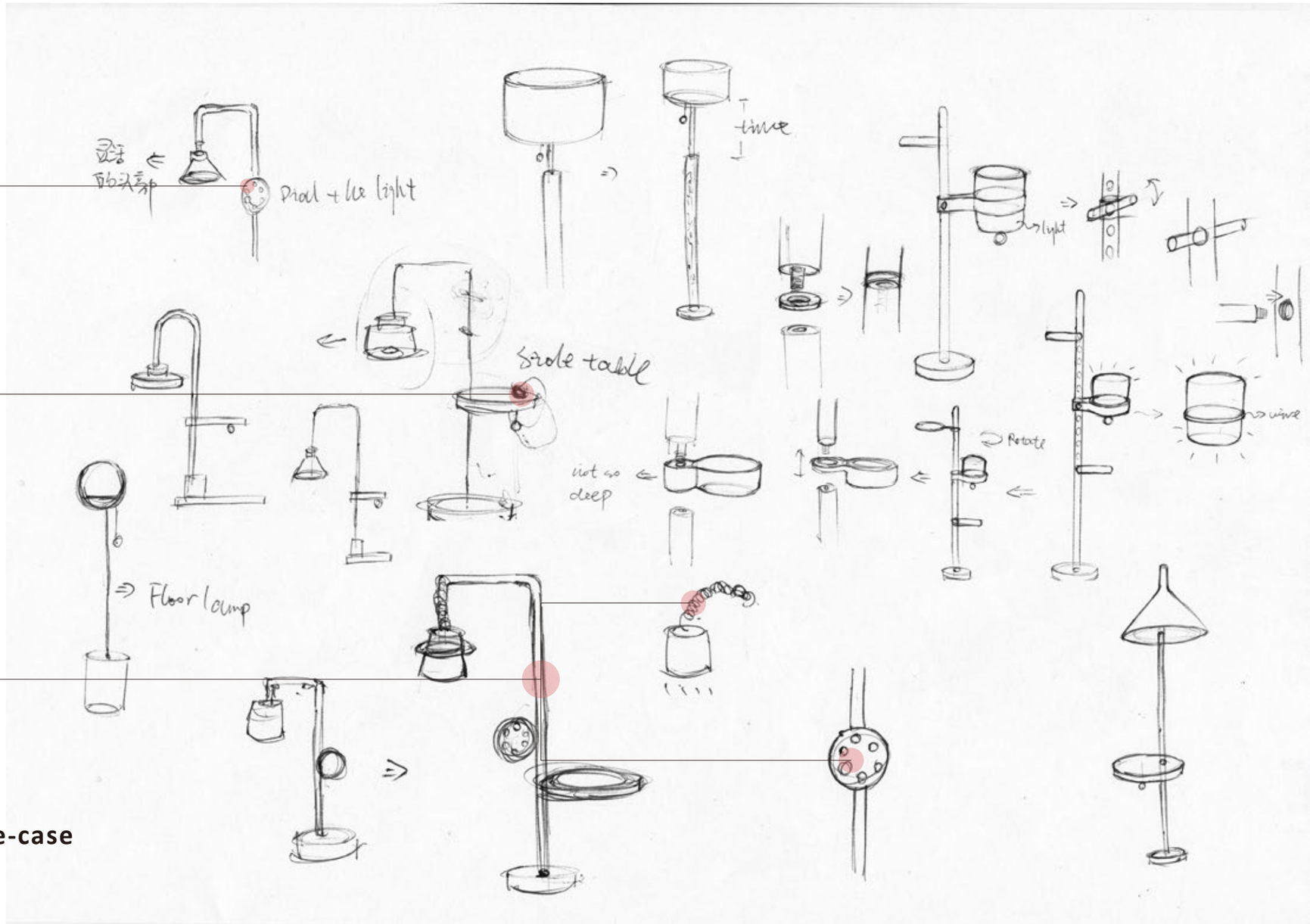
Floor lamp

Separate the timer and the light

Considering the height of the floor lamp and the usage scene, it is best to separate the lamp and the timer, so that the user can set the time more conveniently when sitting. While setting the time, it will not affect the direction of the light.

A floor lamp with a side table

Combine the timer with the side table



Inspired by antique telephone

 # Require more research into the use-case

CONCEPT DEVELOPMENT
Reflections

Compared to turning the dial, pulling the string has some advantages.

Simpler way of interaction

Considering that it is a bedside luminaire, its interaction should be as simple as possible, especially when you wake up at night and want to turn on the light in the dark, it is much easier to turn on the light by pulling the string than by turning the dial.

More intuitive way to show the time passing

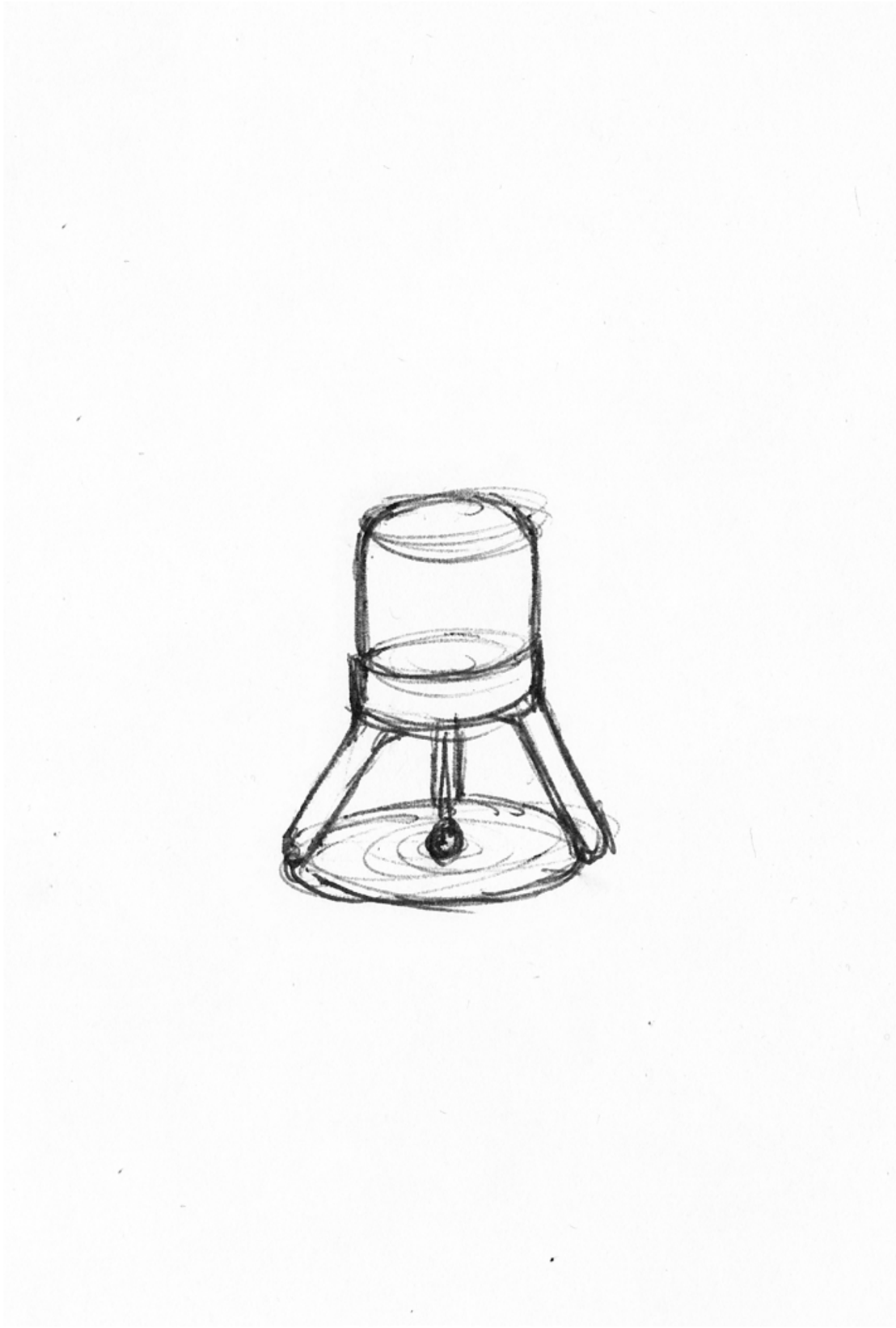
The length of the string you pull determines the time. As time goes by, the string is gradually retracted, which can better make users feel the passage of time.

.

Compared to pulling sideways, the lamp with a central vertical string is much more **easy-going**, you don't need a second hand to hold the lamp.

With a support structure, like legs, the lamp would be more **stable** when pulling the string vertically.

All the electronics can be at the top, so the design would be very **minimalistic**.

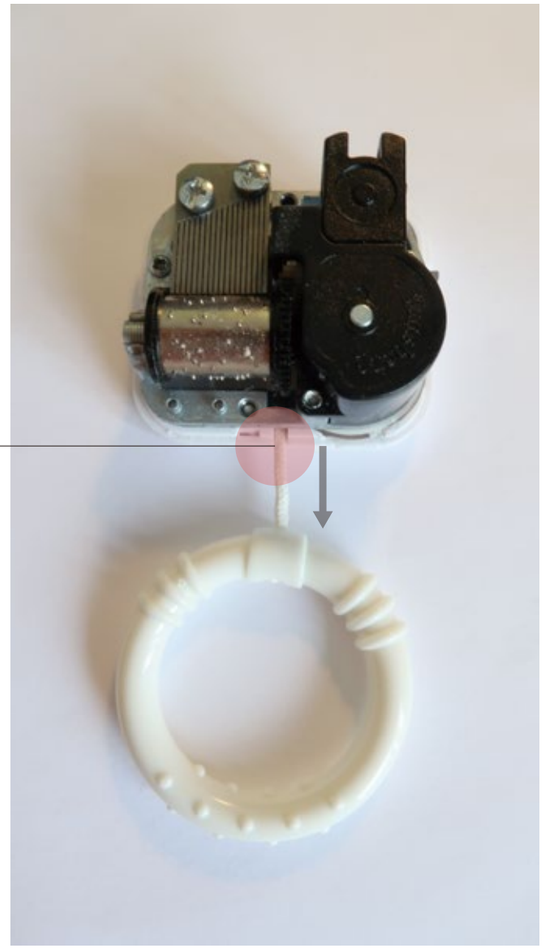


CONCEPT DEVELOPMENT

Structure

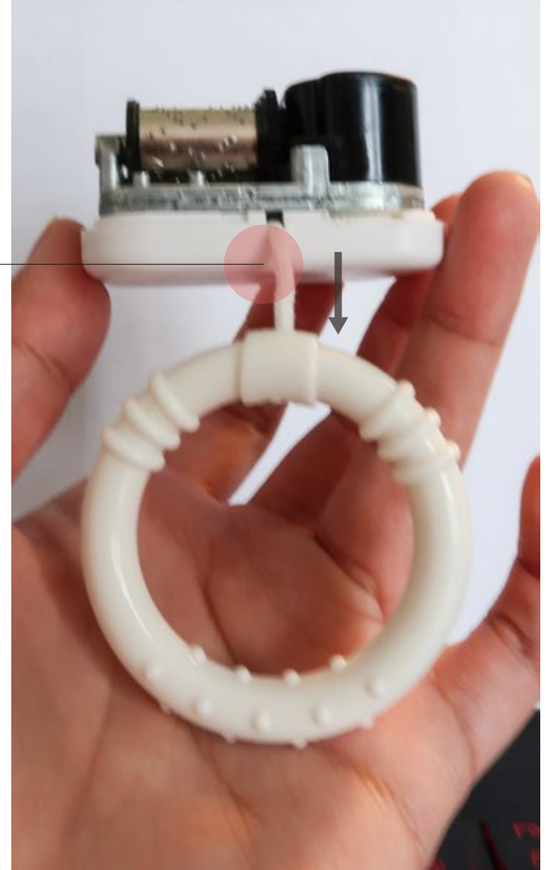
It is easy to pull the string like this.

The pulling direction is perpendicular to the shaft.



It is not easy to pull the string like this.

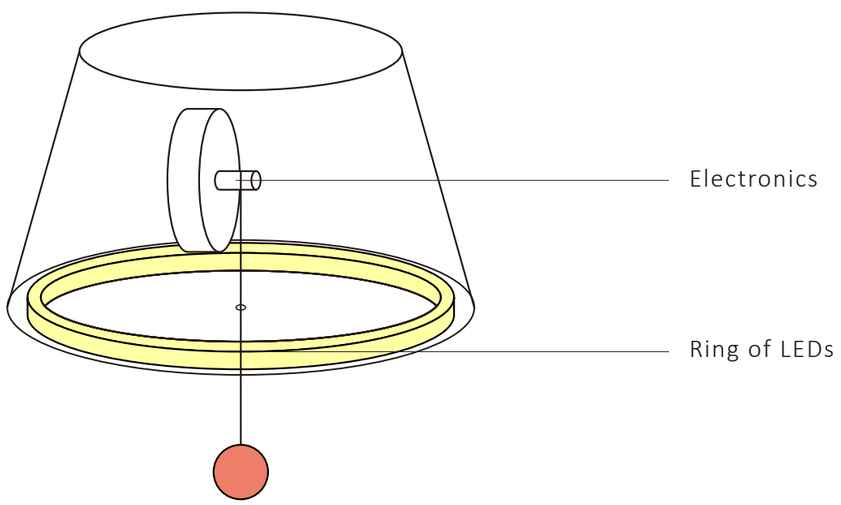
The pulling direction is parallel to the shaft.



CONCEPT DEVELOPMENT

Structure

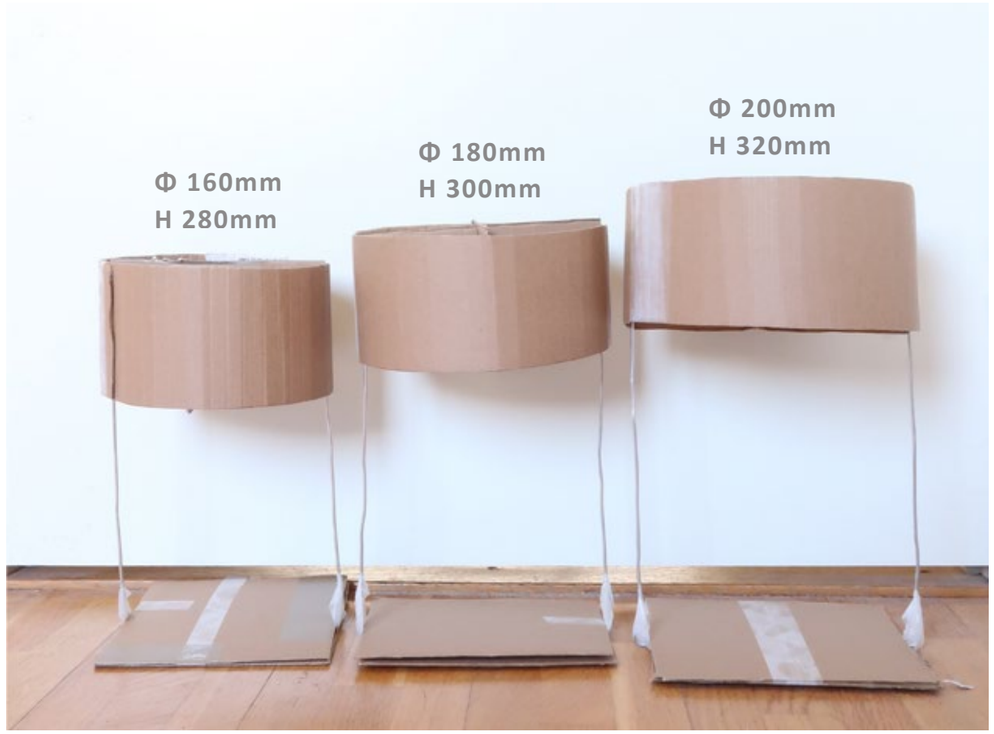
So, if pull vertically, then the mechanical timer should be placed **vertically** in the lamp like this, which may occupy a certain amount of space, so how to organize the internal components of the lamp needs to be considered.

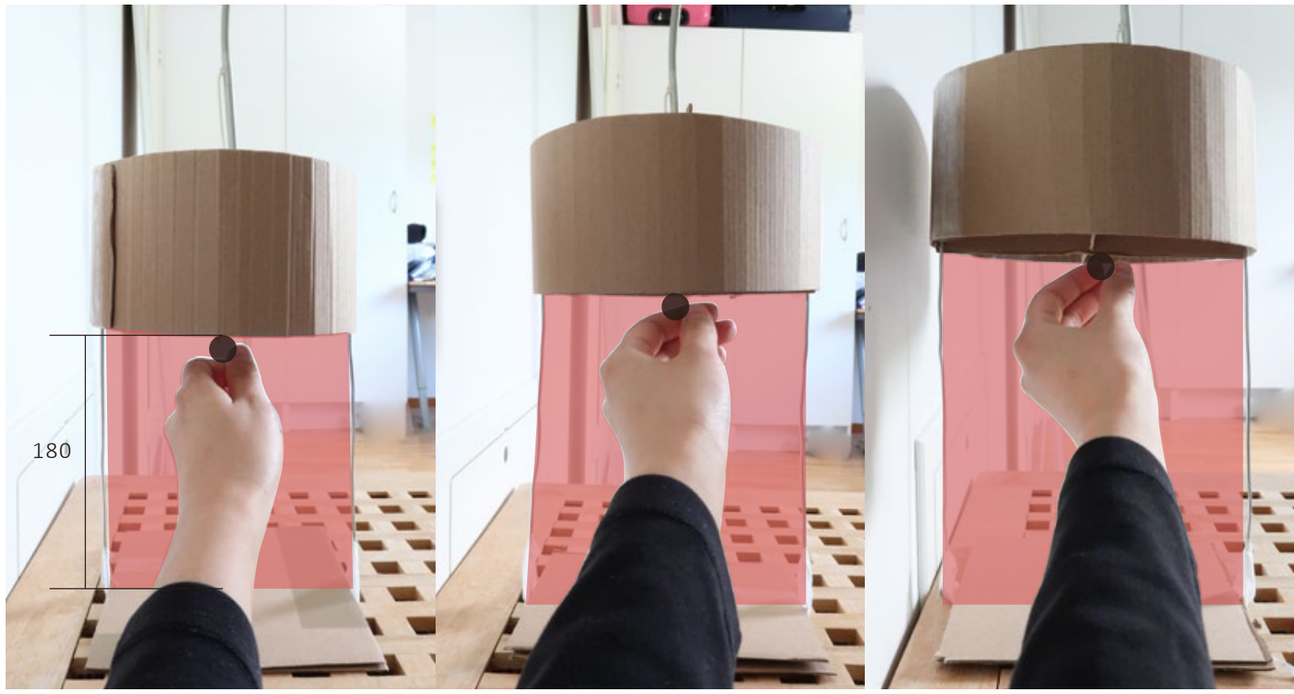


CONCEPT DEVELOPMENT

Size testing

I made some mock-ups to test the size of the lamp. I tested three different sizes with different heights and different diameters. Considering the using scenarios, I tested the mock-ups in bed to see which size is easier to use.





The height of the lamp from top to bottom (the part marked in red) determines the length of the string that can be pulled. If the area is too tight, the length of the string that can be pulled would be limited, making it less intuitive to show the passage of time and making it difficult for users to set the timing. The maximum of the string that can be pulled is preferably not less than 180mm. I also did research on the measurements of the existing bedside lamp, and found that all the sizes I tested were smaller. I would adjust the size of the lamp during the modelling process later.

CONCEPT DEVELOPMENT

Size testing

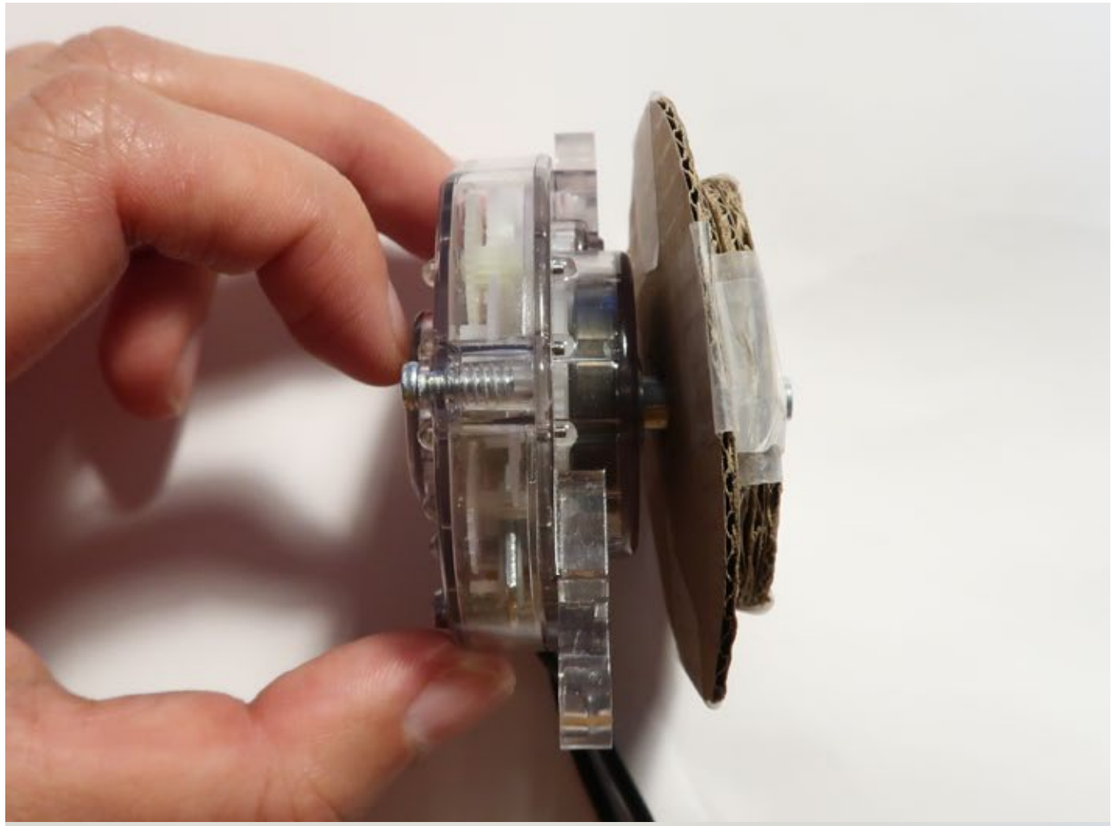
The mechanical timer can only rotate 270 degrees. So, the length of the string that can be pulled depends on the circumference of the string structure. The longer the required length, the larger the diameter of the string structure.

Then the diameter of the string structure will affect the size of the upper part of the lamp. The larger the string structure, the larger the size of the upper part of the lamp.

String length ↑

Diameter of the string sturcture ↑

The size of the upper part of the lamp ↑

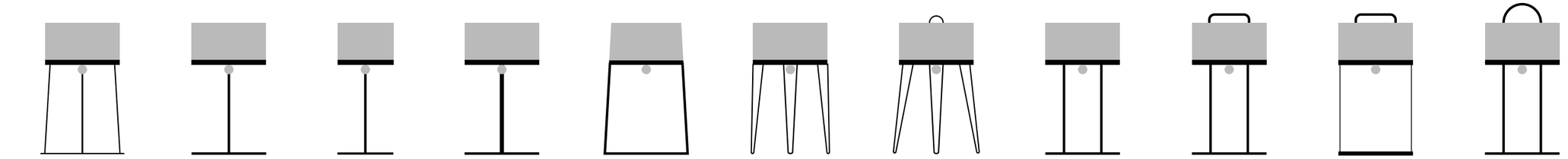


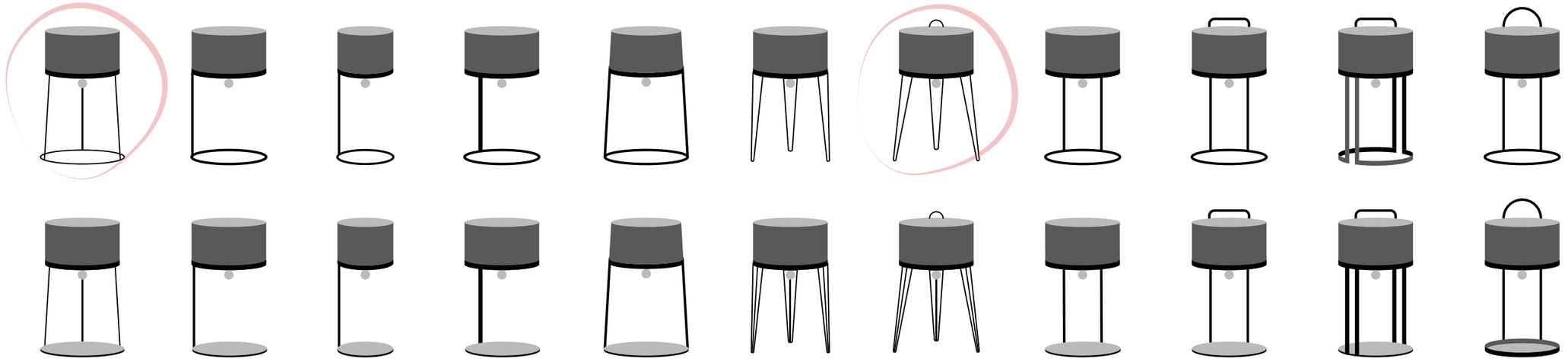
CONCEPT DEVELOPMENT

Form exploration

CONCEPT DEVELOPMENT

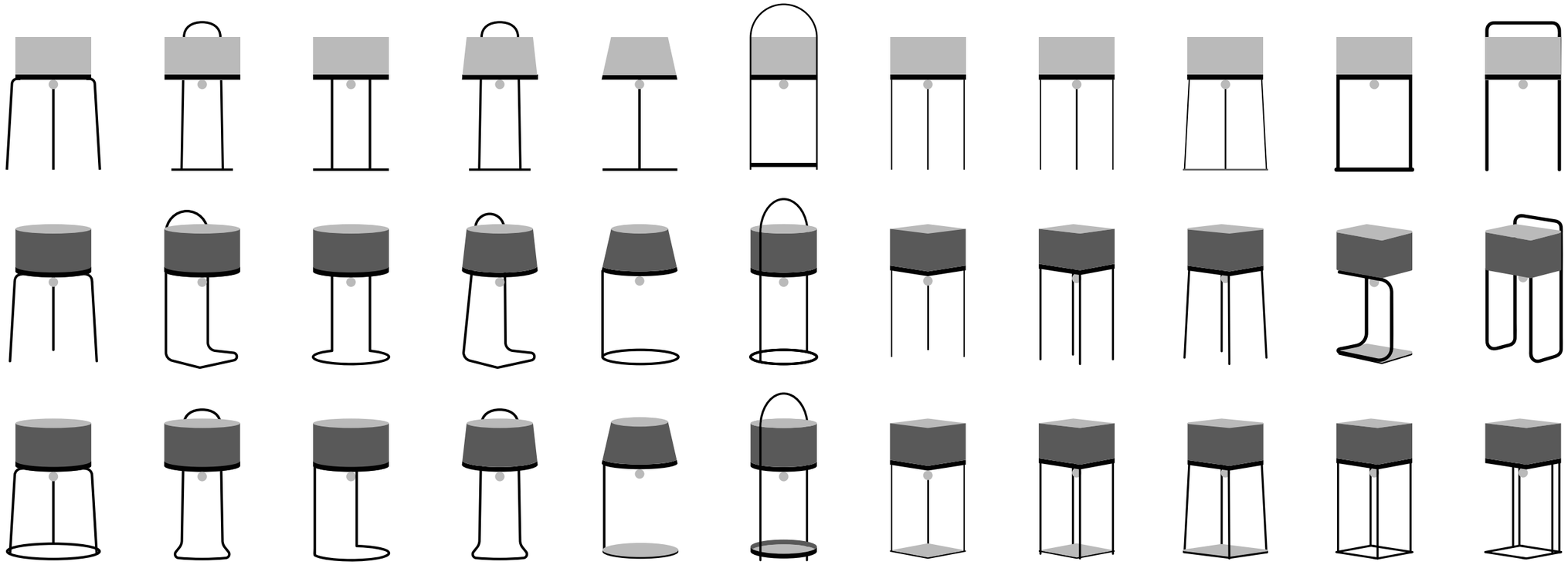
Form exploration





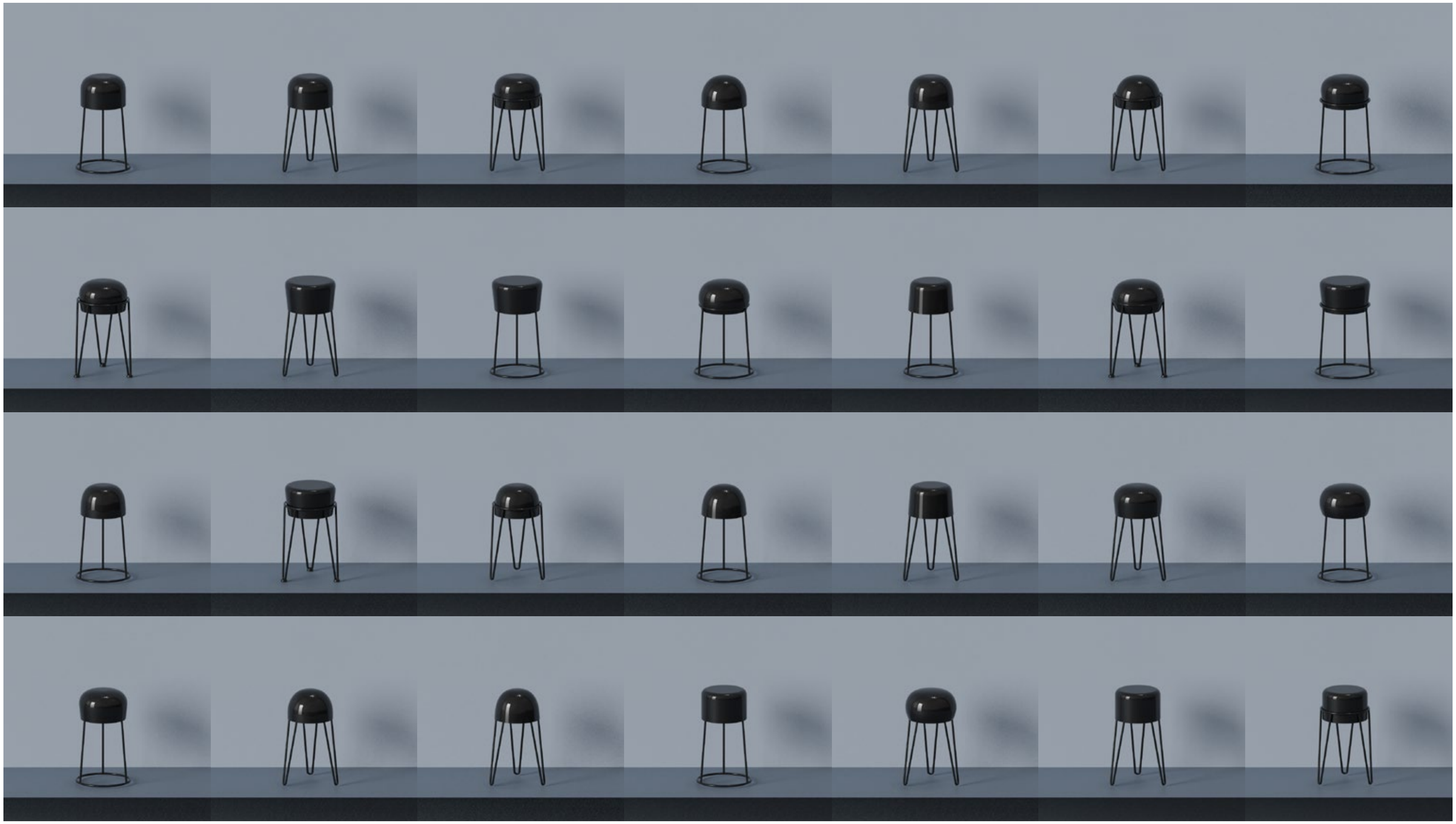
CONCEPT DEVELOPMENT

Form exploration



CONCEPT DEVELOPMENT

Form exploration

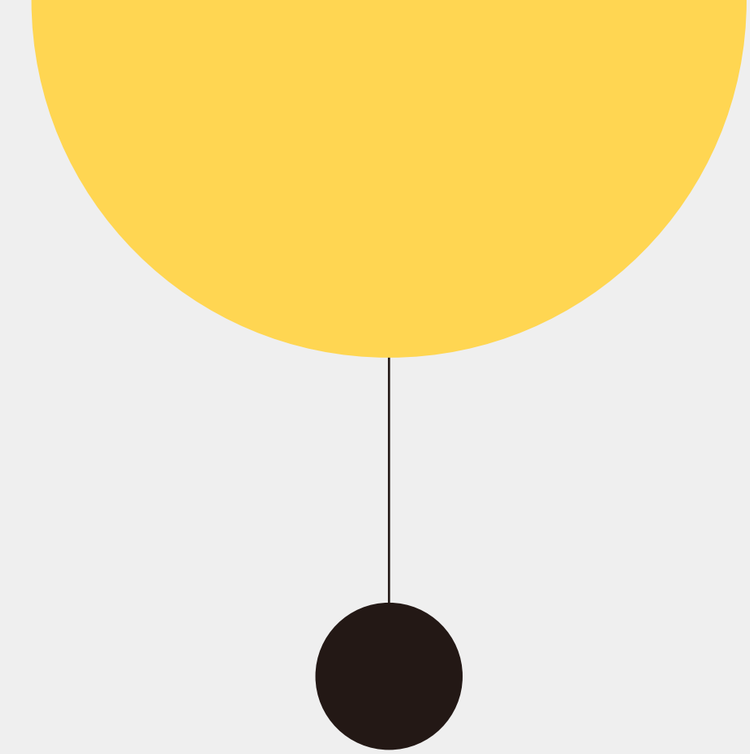


CONCEPT DEVELOPMENT

Form exploration

Compared with other directions, this solution has a more stable support structure, which can be more stable when pulling the string.

In addition, in terms of appearance, its surface of the lampshade picking up on the angle of the wires, making the lamp looks more elegant and minimal.

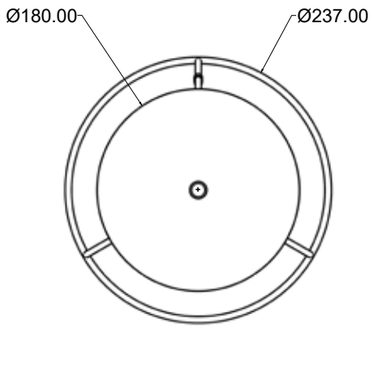


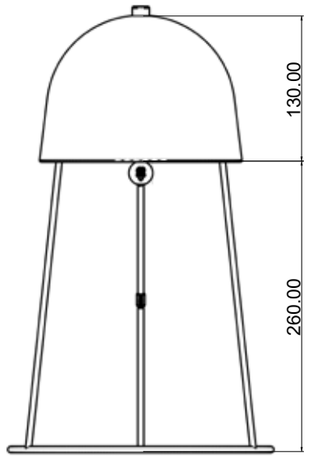
FINAL DESIGN

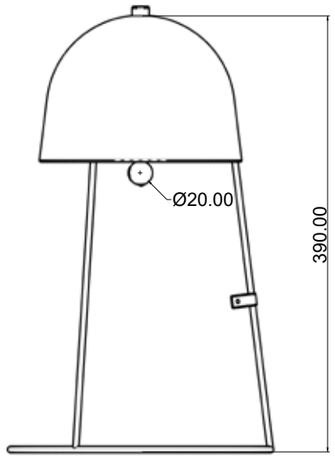
This chapter shows the final design regarding dimensions, the structure, CMF, details design, color design, using scenario, etc.

FINAL DESIGN

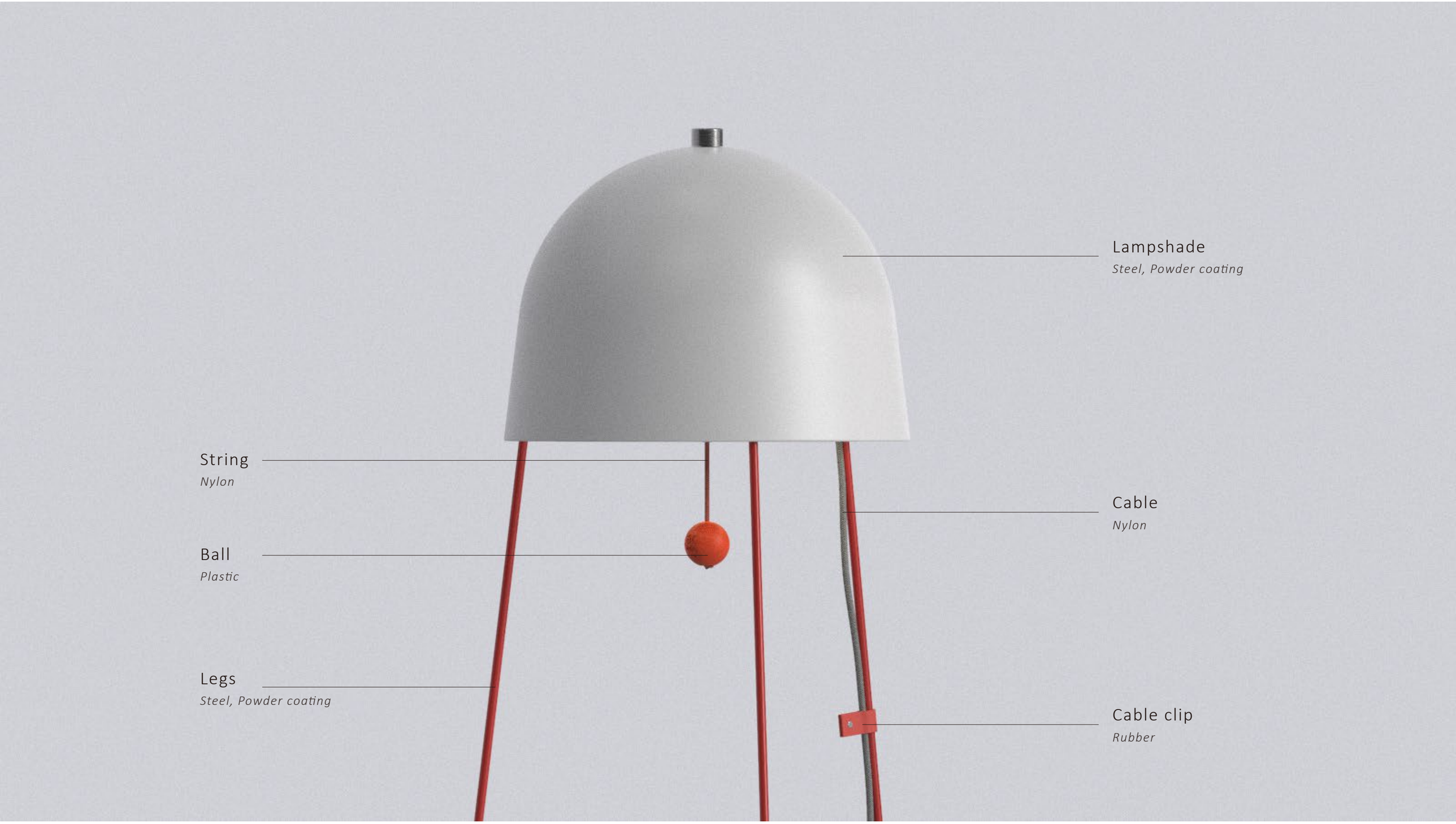
FINAL DESIGN
Dimensions







FINAL DESIGN
Design details



FINAL DESIGN

Design details

Pull the string to set the timer and turn on the light. The length of the string you pull determines the time.

FINAL DESIGN

Design details

Pull the string to set the timer and turn on the light. The length of the string you pull determines the time.

FINAL DESIGN

Design details

The string uses the gradient color to indicate the length of the string the user has pulled, and at the same time to avoid over-pulling.

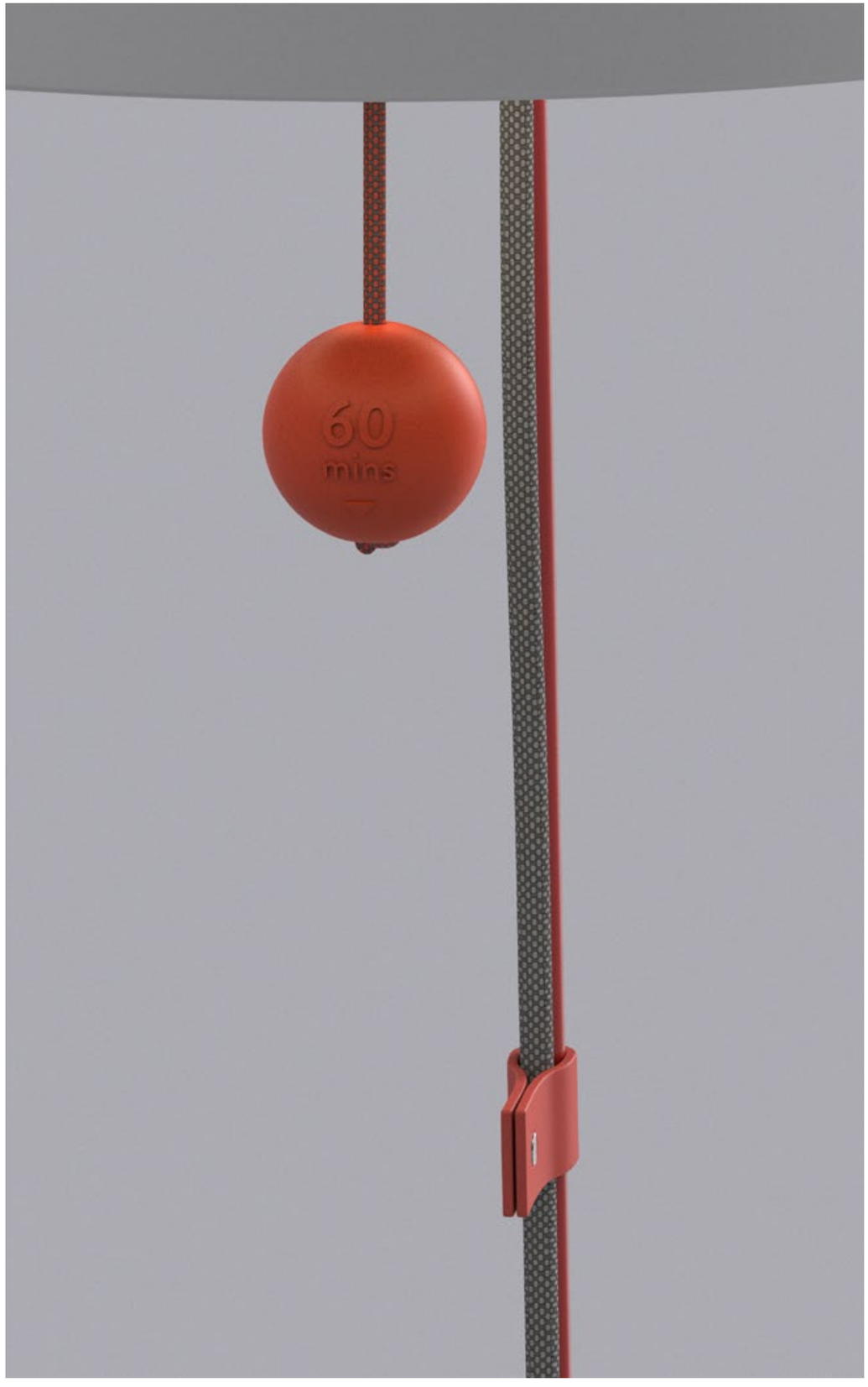
The height of the lower part of the lamp is the maximum length of the string that the user can pull, and also corresponds to the maximum time that can be set.

FINAL DESIGN

Design details

“60 mins”, the maximum set time, is marked on the ball. Under the “60 mins”, a small arrow hints the user to pull the string downwards.

At the same time, the mark on the ball can increase friction and make it easier for people to hold the ball to set the timer.



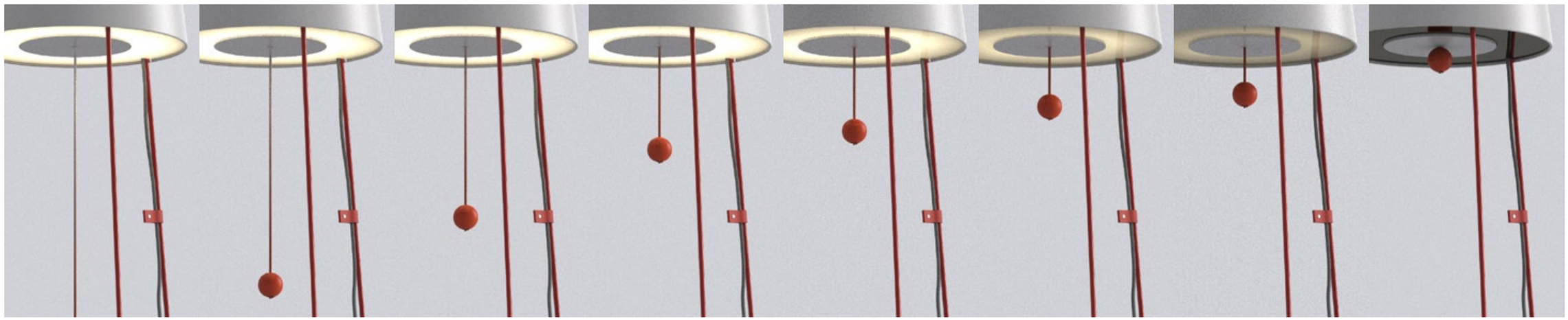
FINAL DESIGN

Design details

About product assembly, all the electronics (the mechanical timer, ring of LEDs, microcontroller, etc.) can be fixed on the legs. And the lampshade can be fixed on the legs by the nut on the top. Then the transparent acrylic sheet is fixed by the threaded part at the bottom.

FINAL DESIGN

Design details

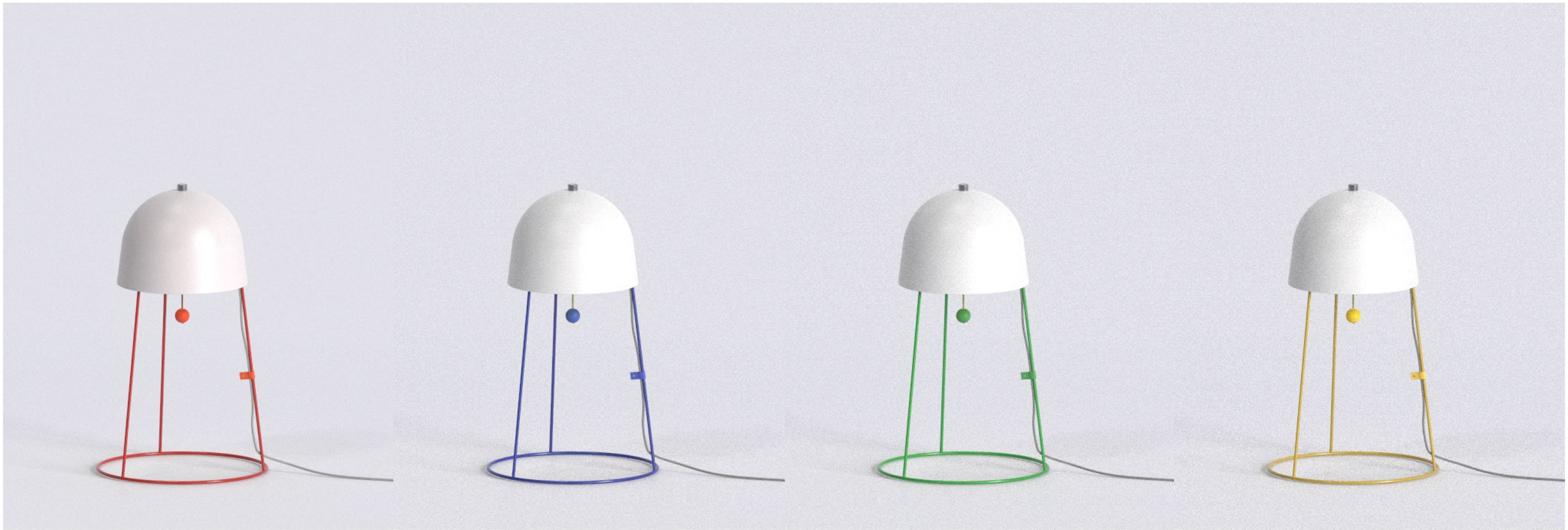


45minutes full light

last 15 minutes slowly ramp down

FINAL DESIGN

Color design



About the color design, considering pulling-the-string interaction is dynamic, I want to use highly saturated, bright, vivid colors to highlight it. So the lower part, the ball and the wires are used these vivid colors, The lampshade uses white to form a contrast to highlight the lower part of the product.

Reflections

In this project, I explored the harmful effects of excessive light exposure at night and people's sleeping habits.

Sleeping with a light on and using electronic devices in bed are both bad sleeping habits that can lead to poor sleep quality and negatively affect our health. I also found light off can be the signal to remind people to sleep. In the final design, I integrated a mechanical timer in the bedside lamp so that users can set the timing while turning on the light.

However, there are still much left for improvement in this project.

First, the structure of the bedside lamp. Actually, I encountered some difficulties when thinking about the product structure and how to assemble it together. I thought about it for a long time and researched the lamps on the market before I came up with the final solution. But the final solution still needs certain tests to know whether it is the smartest solution.

Secondly, the switch of the lamp. In the final design, I didn't add another switch to the lamp, since the maximum set time 1 hour is not too long, and users can set anytime during this 1 hour and the light would dim in last 15 minutes. The only switch is the ball, pull the string to turn on the light and set the timer. I also thought it without another switch would make users set the time much more carefully before they pull the string. However, without another switch, users can't retract the string to shorten the time, which may cause some problems. So, whether it is necessary to add a switch needs to be tested.

Thirdly, due to COVID-19, I have no chance to make the final prototype. I will try to make a full-scale and functional prototype later.

In addition, I also found a problem of myself. I have a tendency to overthink problems, which results in a lot of time being lost in the process. I need to remind myself that the product must be simple and minimal while realizing the function in subsequent designs.

Overall, I'm satified with what I have done and learned a lot during the process. And thank you again to my supervisor and examiner!

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