Forming LED

DESIGN EXPLORATORY PROJECT (DES)

IDC School of Design
DEP502

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Understanding LED

Functioning of LED

LED stands for a Light-Emitting Diode. LEDs generate light from a semiconductor material through the process of electroluminescence. Electroluminescence is the phenomenon of a material emitting light when an electric current or an electric field is passed through it - this happens when electrons are sent through the material and fill electron holes. An electron-hole exists where an atom lacks electrons (negatively charged) and therefore has a positive charge. Semiconductor materials like germanium or silicon can be "doped" to create and control the number of electron holes. Doping is the adding of other elements to the semiconductor material to change its properties. By doping a semiconductor you can make two separate types of semiconductors in the same crystal. The boundary between the two types is called a p-n junction. The junction only allows current to pass through it one way, this is why they are used as diodes. LEDs are made using p-n junctions. As electrons pass through one crystal to the other they fill electron holes they emit photons (light)[1].

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[1] https://edisontechcenter.org/LED.html
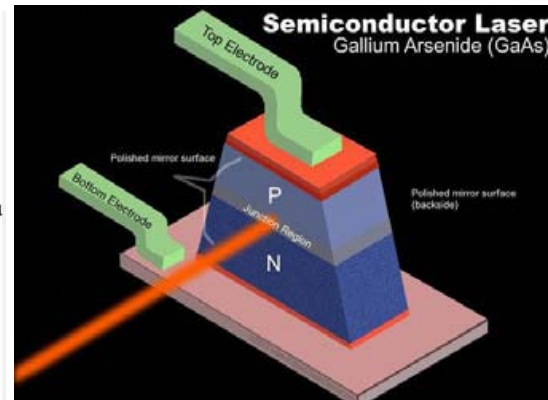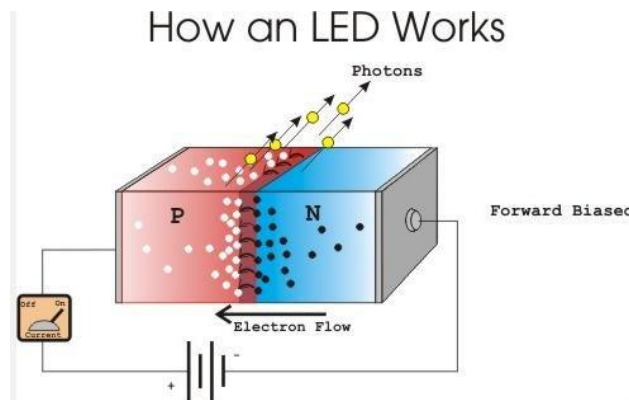
Advantages and Applications

LEDs have many advantages over incandescent light sources, including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. LEDs are used in applications as diverse as aviation lighting, fairy lights, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, lighted wallpaper, horticultural grow lights, and medical devices.

Color

The light emitted from an LED is neither spectrally coherent nor even highly monochromatic. However, its spectrum is sufficiently narrow that it appears to the human eye as a pure (saturated) color. Also unlike most lasers, its radiation is not spatially coherent, so it cannot approach the very high brightnesses characteristic of lasers.[2]

The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. Semiconductors made from different materials are used or doped in specific fashion to achieve a particular color. LEDs can emit light in a narrow band of wavelengths from near-infrared through the visible spectrum and into the ultraviolet range.

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Red and Infrared LEDs are made with gallium arsenide. Bright Blue is made with GaN -gallium nitride. White LEDs are made with yttrium aluminum garnet. There are also orange, green, blue, violet, purple, ultraviolet LEDs.

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[2] https://www.energy.gov/eere/ssl/led-basics

RGB LED

RGB LEDs are a type of Tri-color LED which consist of one red, one green, and one blue LED. By independently adjusting each of the three, RGB LEDs are capable of producing a wide color gamut. Unlike dedicated-color LEDs, however, these do not produce pure wavelengths.

Tri-color LEDs contain three different LED emitters in one case. Each emitter is connected to a separate lead so they can be controlled independently. A four-lead arrangement is typical with one common lead (anode or cathode) and an additional lead for each color. Others, however, have only two leads (positive and negative) and have a built-in electronic controller.

Inspiration

I have been fascinated by the effects light creates when used in long exposure photography. The ability of light to highlight movements in a mesmerising fashion and add a sense of dynamism to still photography could be a powerful tool to generate interesting outcomes.

Additionally in a previous project I explored the notion of Free will with respect to designers to understand what could help one to break free from deterministic or sequential thinking and be more free and creative. What tools could help a designer to maximise their own influence and control in decision-making while minimising the effect of external sources.

I discovered the importance of randomness and juxtaposition to stimulate a complex chain of thoughts to maximise inputs for designers' individual minds and their mental models.


Hence through this project I wanted to create a tool that could create random shapes and patterns in the 3D space which could be captured using long exposure photography.

# Secondary Research

Double Pendulum

A double pendulum is a pendulum with another pendulum attached to its end. It is the simplest representation of a pure mathematically chaotic system. There are multiple examples available online of light attached to the second pendulum to highlight its motion and create unique and chaotic motion every time. But one of the biggest limitations is that its motion is limited to a 2D plane.
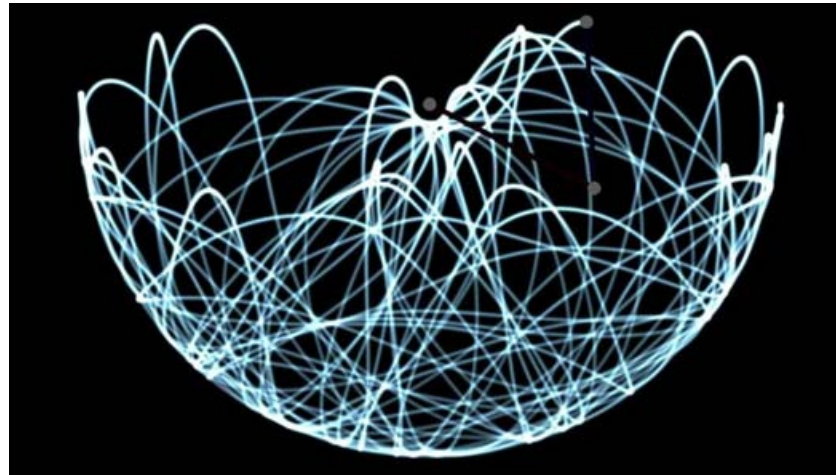
Chaotic motion toys

There are numerous toys available online which use magnetic fields to create unique and random oscillations in the 3D space. They usually have magnetic weight attached which is free to move on a pivot point and oscillates normally under the gravitational pull but it has few magnets attached to the bottom which repel the weight. It is this play between the gravitational force pulling the weight down and the magnetic force pushing it upward which creates unique motions.
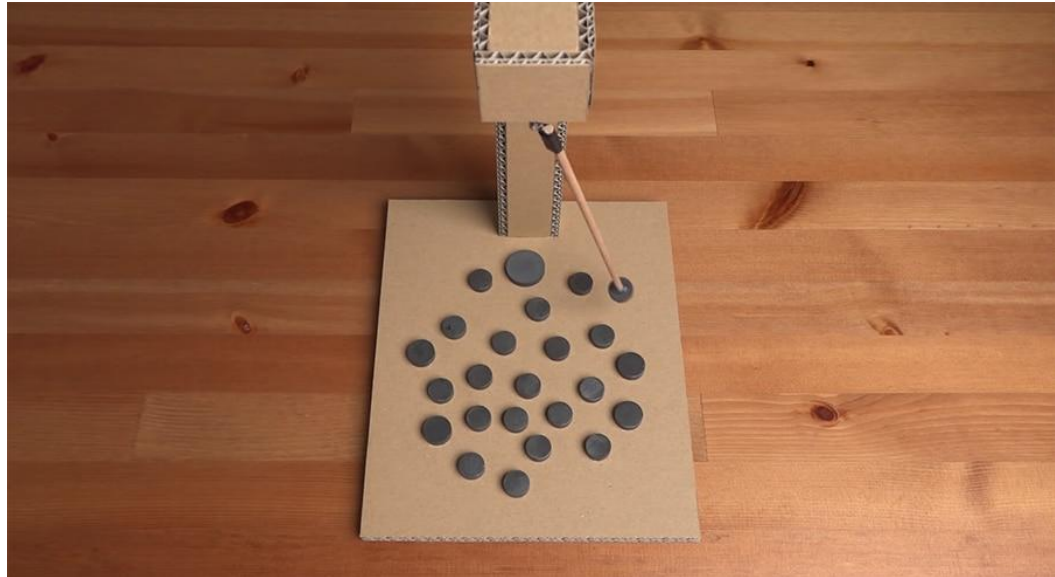
Ideation

I began ideation on various rigs that could either use magnets or gravity to create free and unique movements at a point on which I could attach a light later on. I started exploring various settings for a gyroscopic-like enclosure which allowed free movements on various axes. I began evaluating what was the neatest organisation and the least amount of free axis required to create as free and random movements in the biggest 3D volume possible.

On the above mentioned criterias I started moving ahead with the direction of an apparatus with two C like shapes which could move freely on perpendicular axis which allowed the middle point on the inner C to be anywhere on a large spherical volume while the larger C is mounted to a stand as well as the entire thing could used handheld to create even more random patterns.
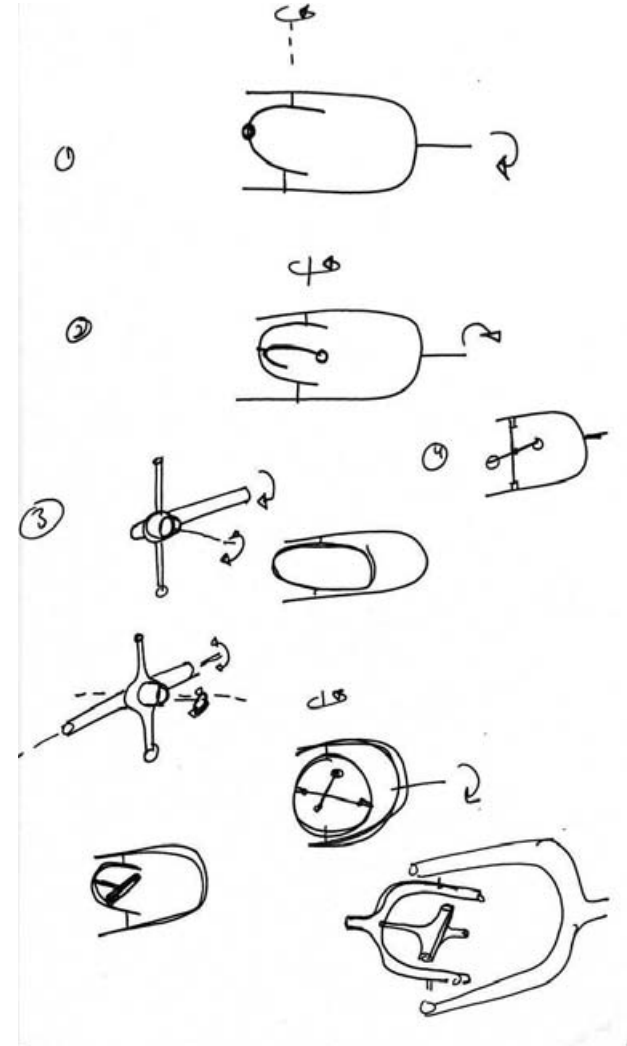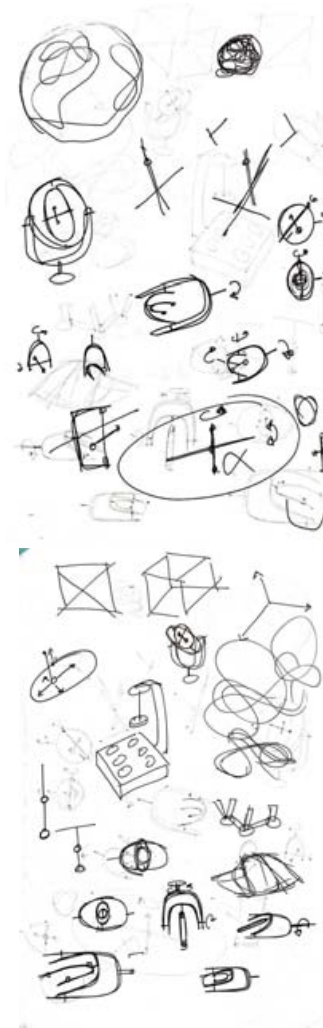
Prototyping

LEDs

To make the prototypes I procured two different kinds of LED which come with their own advantages. First one was a string of very small yellow LEDs which were powered by three small battery cells attached to the LED wire in an enclosure. The enclosure also had a switch to turn the LEDs on and off. This required very less electricity to power it and as the power house is small and already attached it would make it easier to attach it in the final product. The second was a strip of RGB LED lights. The strip was powered by a standard 5V USB-A port and came with a controller attached to the strip which could be used to change the color to a wide range of colors as well as to change to numerous modes like blinking and gradient changing color from one to another. Image of both the LEDs are attached below.

Proof of Concept

To test out the idea I modelled a simple 3D rig in Fusion 360. I 3D printed out the two separate parts which could be fixed by snapping into the dedicated hole, ensuring a free movement of the inner C. I attached steel bearings on the inner C as counterbalance because of the asymmetric shape. Then I taped the yellow LED light on the Inner C and moved it around handheld while taking a long exposure photo of the same. The end result is attached below and it served as a proof of the concept.

Fabrication Process

After getting the idea about the dimensions and proportions of the product from the prototype I started developing a detailed 3D model in Fusion 360 with enclosures to hold the LED lights, hole for the light to shine through, proper channels for wire to flow through as well as enclosure to put steel bearings as counterweight within the inner C. I modelled a stand for the entire rig as well to be used on a desktop. Image of the 3D model is attached below.
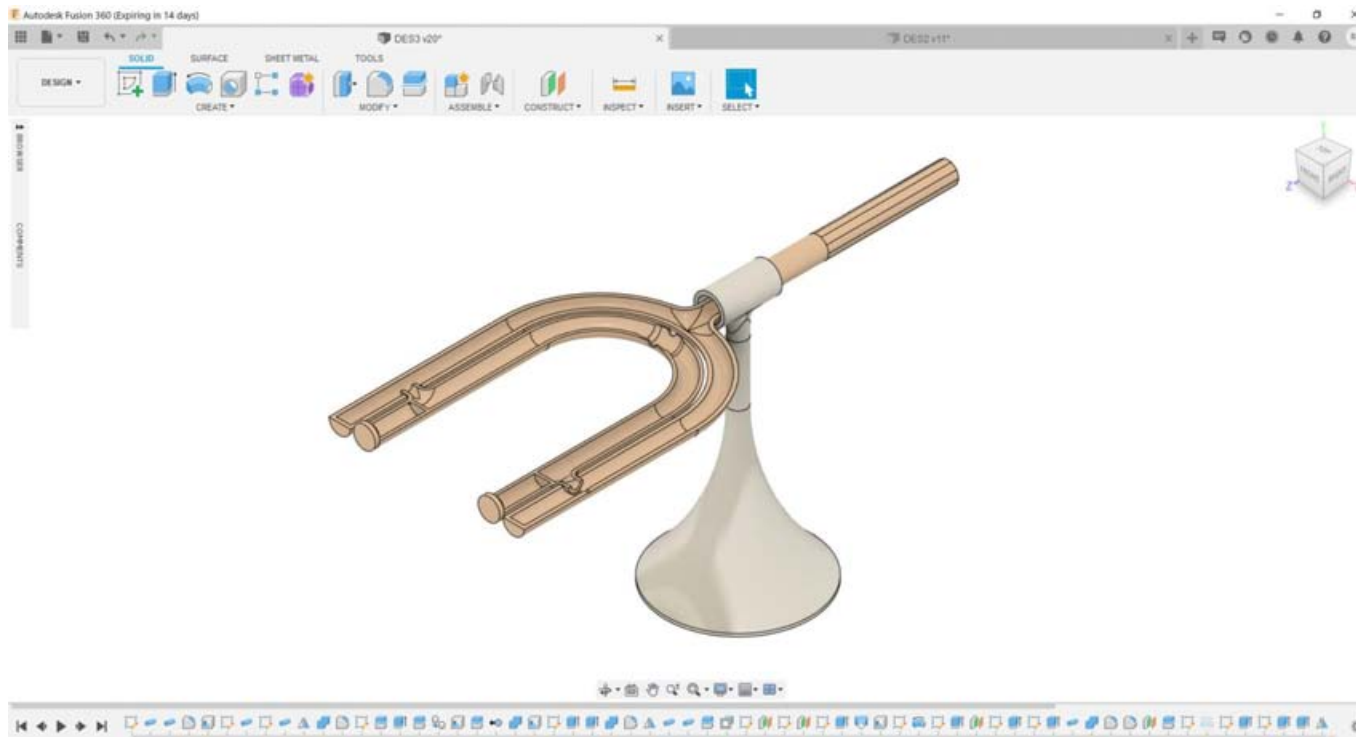
Then I sliced the 3D files in Ultimaker Cura to be sent to the 3D printer to be printed. I used a wood filament for the rig and white PLA filament for the stand to create a contrast in the product. Images of the same are attached below.
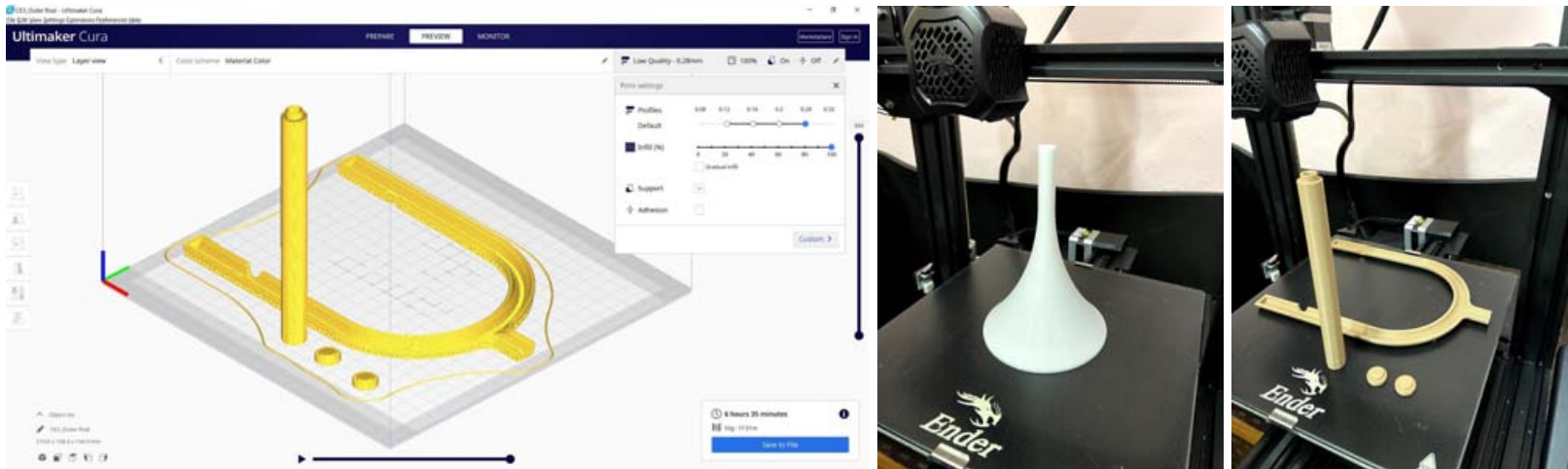
Next up I sanded the irregularities in the printed parts to smoothen out the edges and the surfaces to ensure free and easy movement between different parts.

Then I cut off a small part from the LED strip containing 2 RGB LEDs. I soldered the wires for the four connections on the strip to be sent to the controller and then the power supply. Then I covered the connection with heat shrink tube to ensure strong connection.

After fixing the two LEDs next to the dedicated holes for the light to come out of the inner C, I temporarily closed the entire rig with tape to test it out. But as it turns out the four wires needed to control the RGB LEDs hindered movement of the inner C within the outer C. Hence I had to switch to yellow LEDs because of their thinner wires.

I took measurement of the insides of the inner C and temporarily fixed the light wire on the inside. I folded the wire in a neat fashion ensuring a good amount of LEDs near the two holes and then I blacked out the rest of the LEDs with electrical tape to ensure there is no excess light which might cause issues in the final long exposure photos.

Then I temporarily closed the rig with tape while ensuring the wire attaching the LEDs with the battery enclosure going through the dedicated hole in the outer C. Then I fixed the battery enclosure with the outer C. After attaching the rod with the outer C, I tried out the mechanism and the inner C was moving freely within the outer C and everything was working as intended.

Then I attached the two parts of the stand together with feviquick. I printed the stand in two parts to greatly reduce the printing time as well as to ensure good quality of the parts.

After putting the steel bearings in the housing inside the inner C as counterweight and covering with the caps I assembled the rest of the parts of the rig properly with feviquick.

Final Product

Images of the Final product are attached below. The product could be used either in handheld mode and moved around with your arm and wrist or while kept on a desk and rotated by pulling the rope wrapped around the rod attached with outer C. Small weights could also be added at the end of the rope and left hanging from the edge of the table to have it slowly rotate by itself as the weights go down due to gravity.
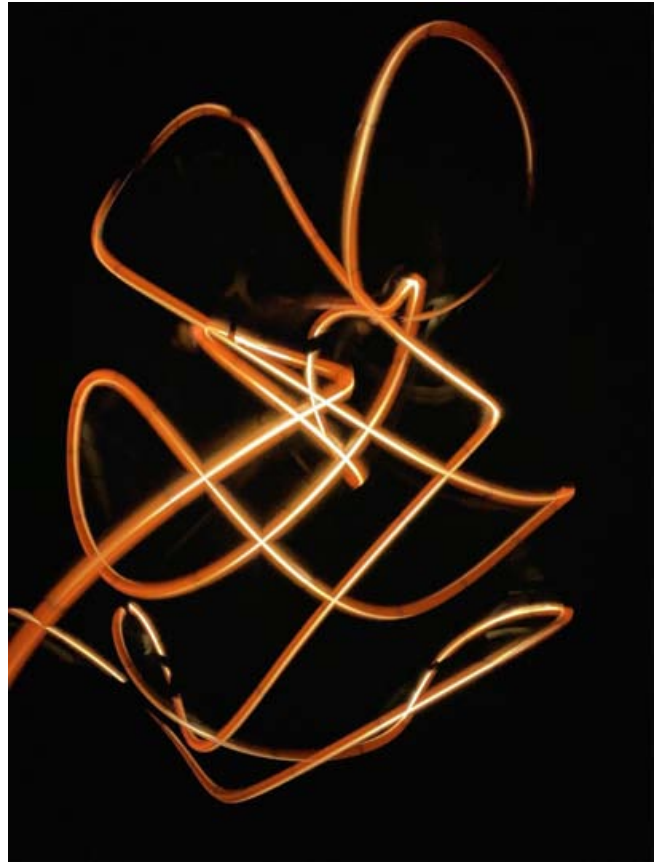
Testing

To test the product I put my phone on a small tripod and used the Moment camera app to take long exposure photos. The app exports both images as well as short gifs of the long exposure capturing the movement even better.
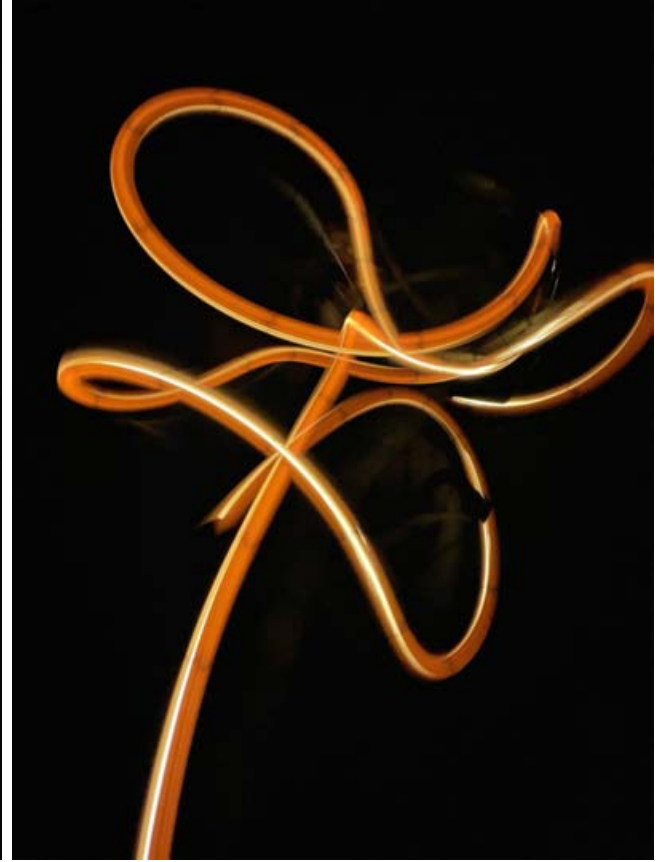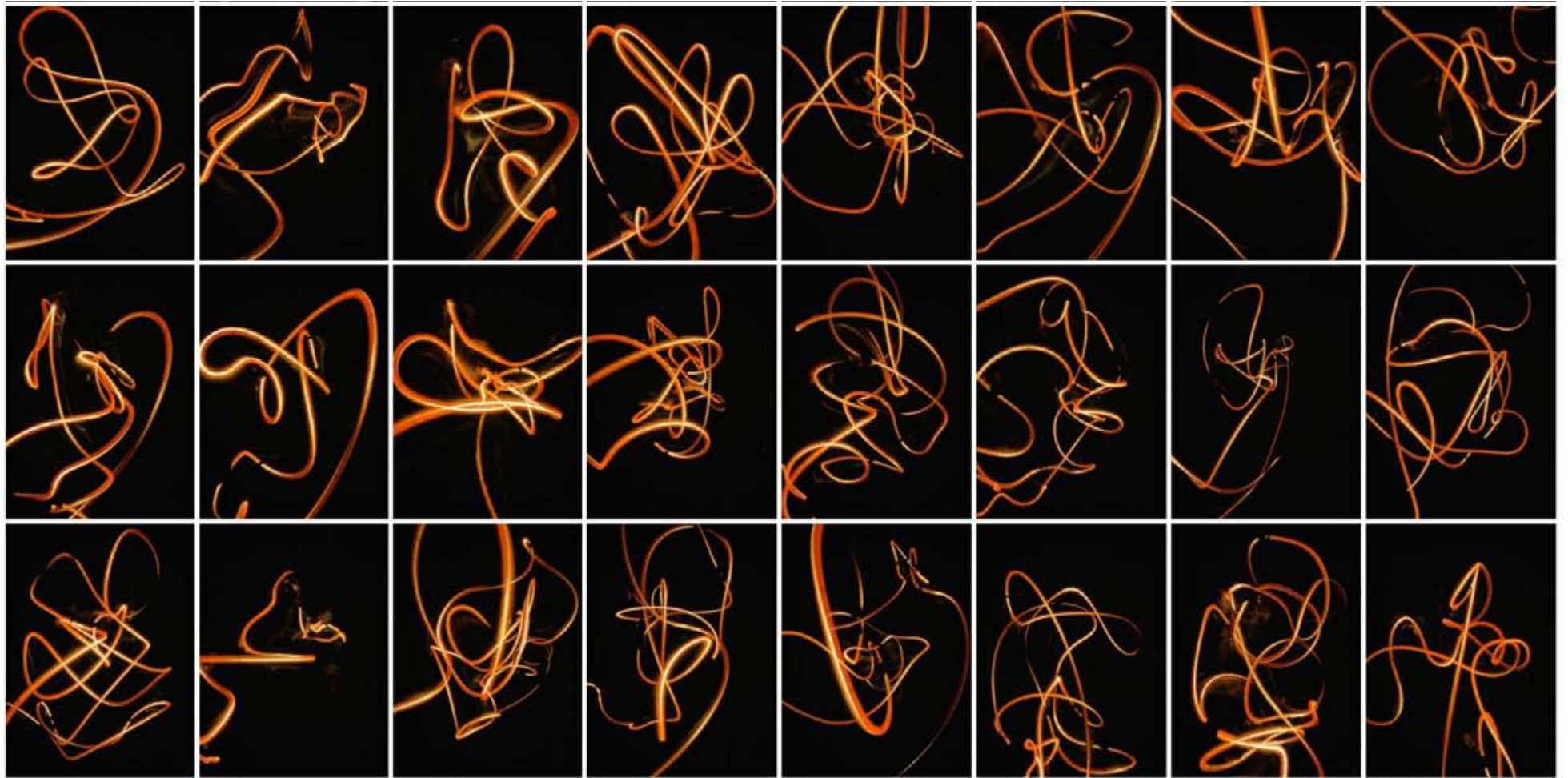
Desktop
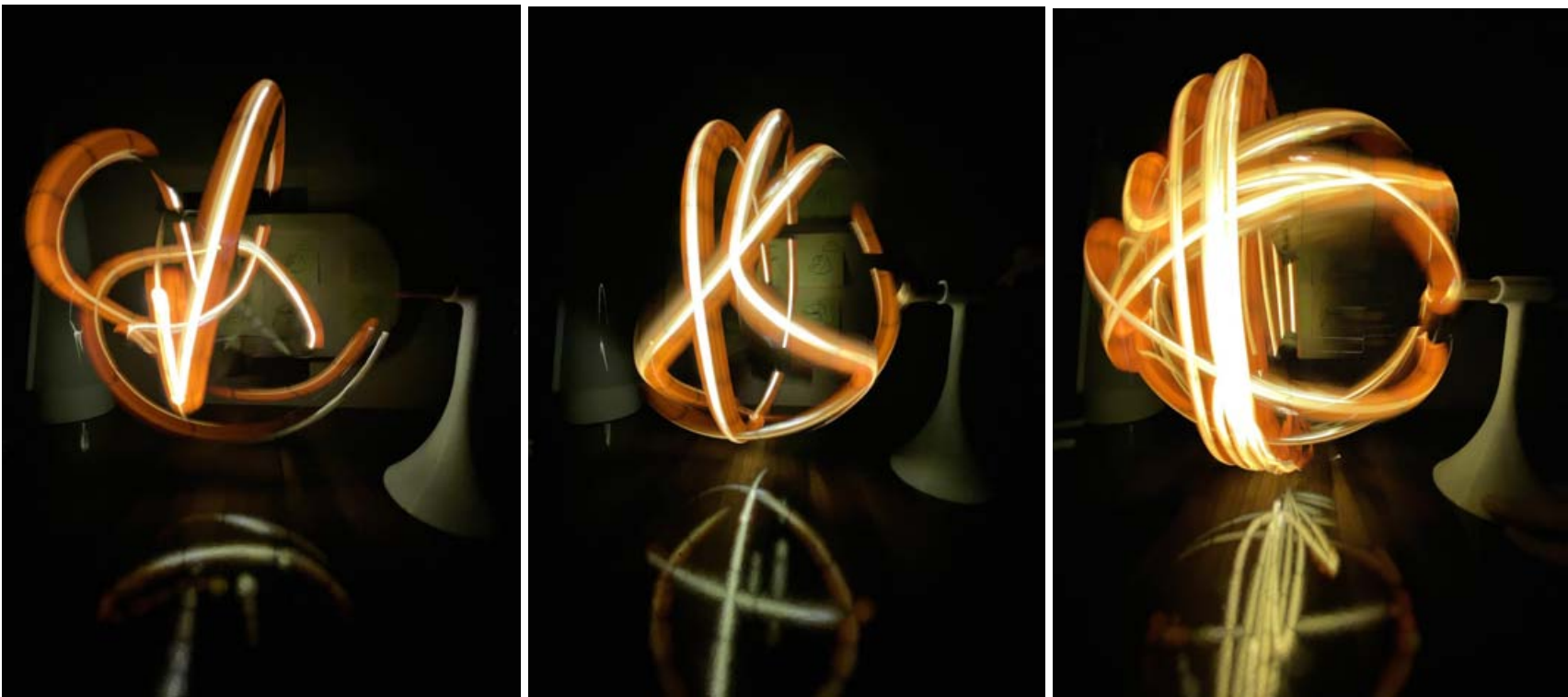
Handheld

Conclusion

The project succeeds in creating random and abstract light-scapes in the 3D domain. This project provides a designer or an artist the opportunity to indulge in a creative activity to find inspiration for 3D forms especially while going through a creative block. During the project I ran into some problems with the 3D printer and was unable to print anything. After almost a week of troubleshooting I located the problem to be a broken part in the filament extruder. Through this entire process I learnt a great deal about the functioning of a 3D printer and how various components work together in one. This project also gave me the opportunity to work on electrical connections on work with a soldering iron which was an exciting learning experience for me.

The apparatus could be improved by using better fabrication methods that would ensure smooth surfaces at the joints which would allow free movement at the joint with minimal friction. The inner C in the apparatus could be tweaked slightly to ensure an even better balance between the side with the Light and the other side with steel balls as counter-weight.

In the future the project could be developed even more by incorporating freedom of movement along more axis and by using a RGB LED that could be controlled to change color or even different modes like transitioning colors in a gradient. Magnets could be used within the apparatus to use magnetic forces to create even more random ligh-scapes.