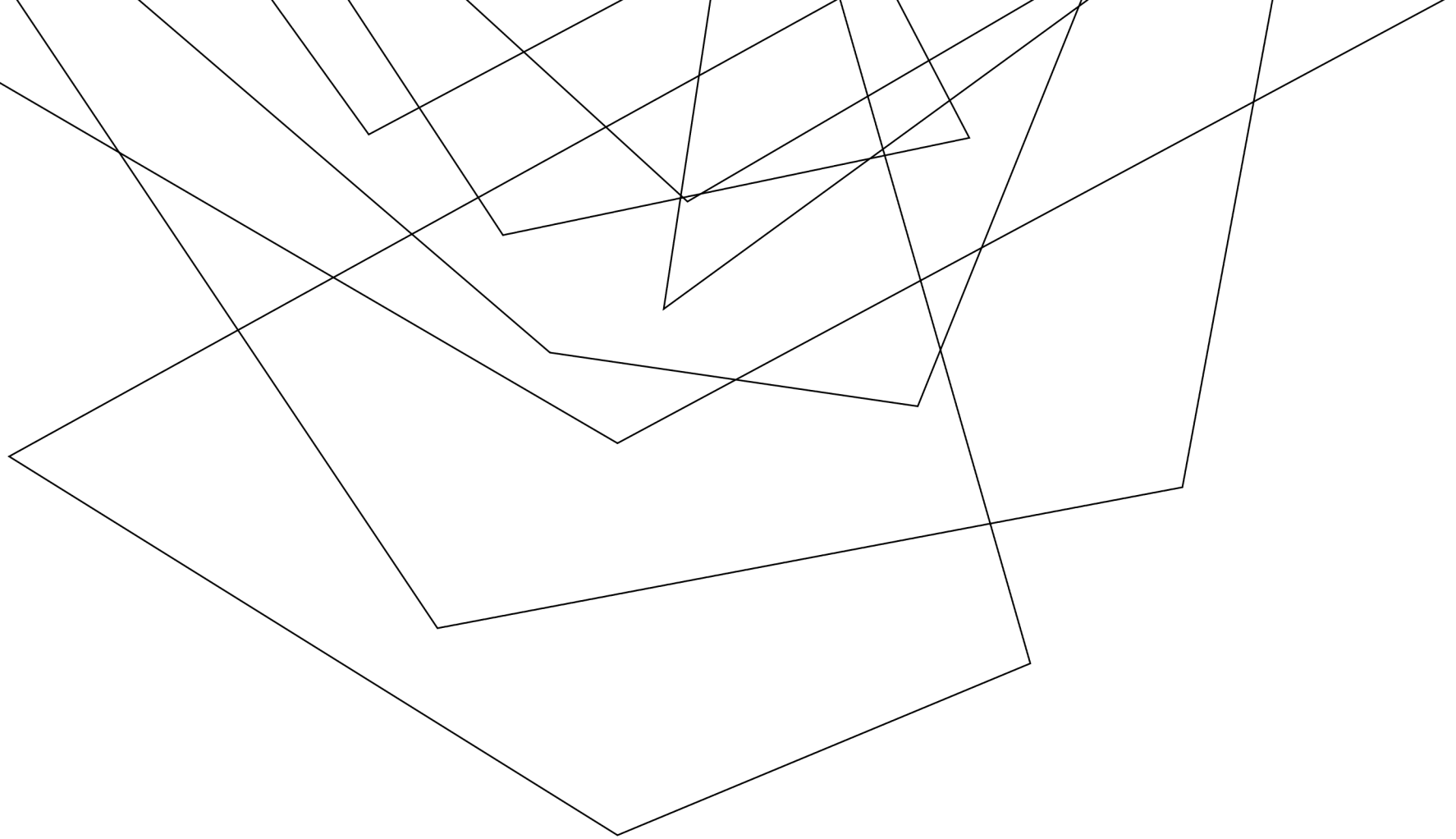

STAR STAR, NEAR AND FAR

The Effect of Distance on the Light Intensity from Different Sources

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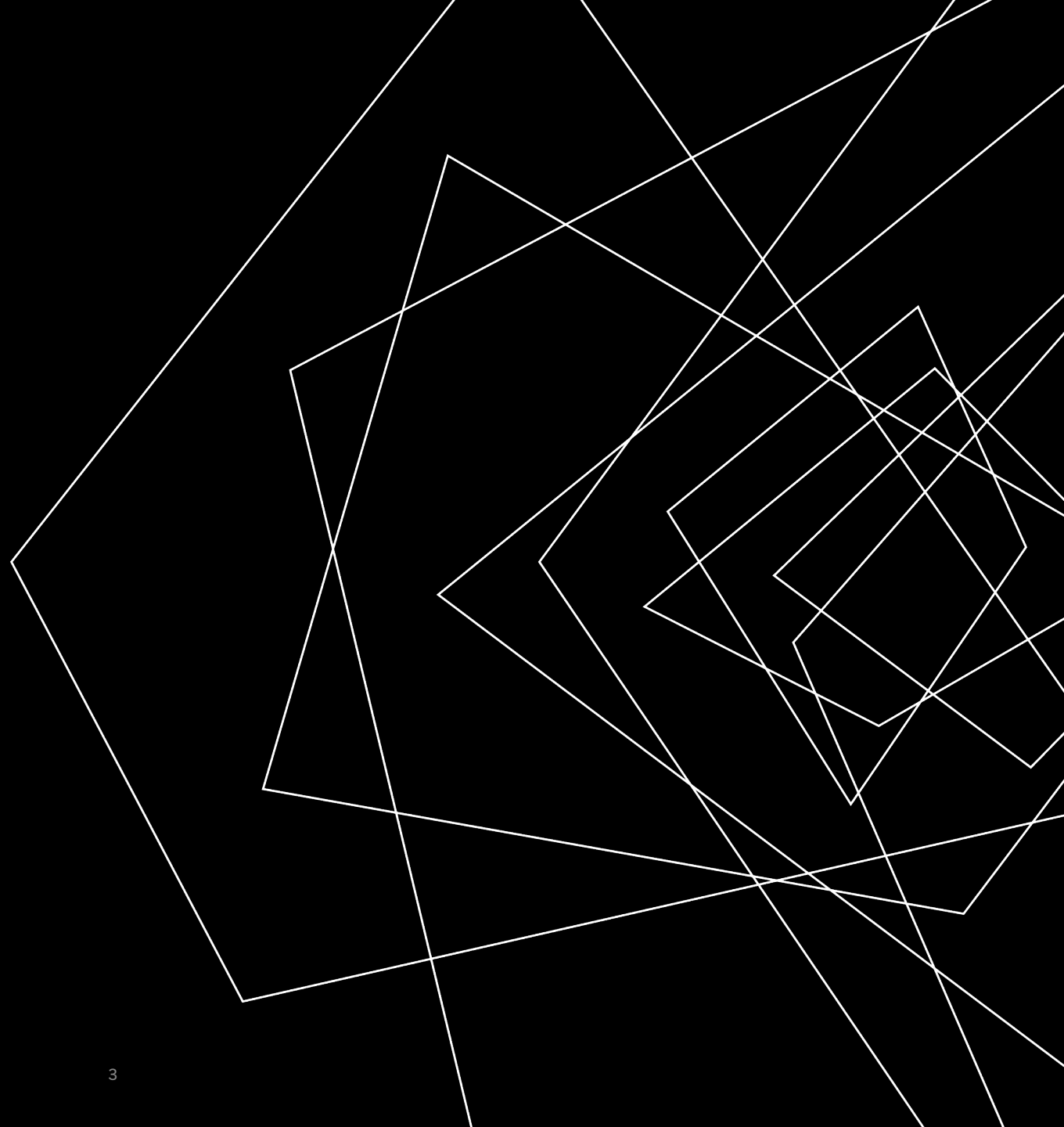
OUTLINE

- Motivation
- Hypothesis
- Experimental Setup and Equipment
- Data and Analysis
- Conclusion

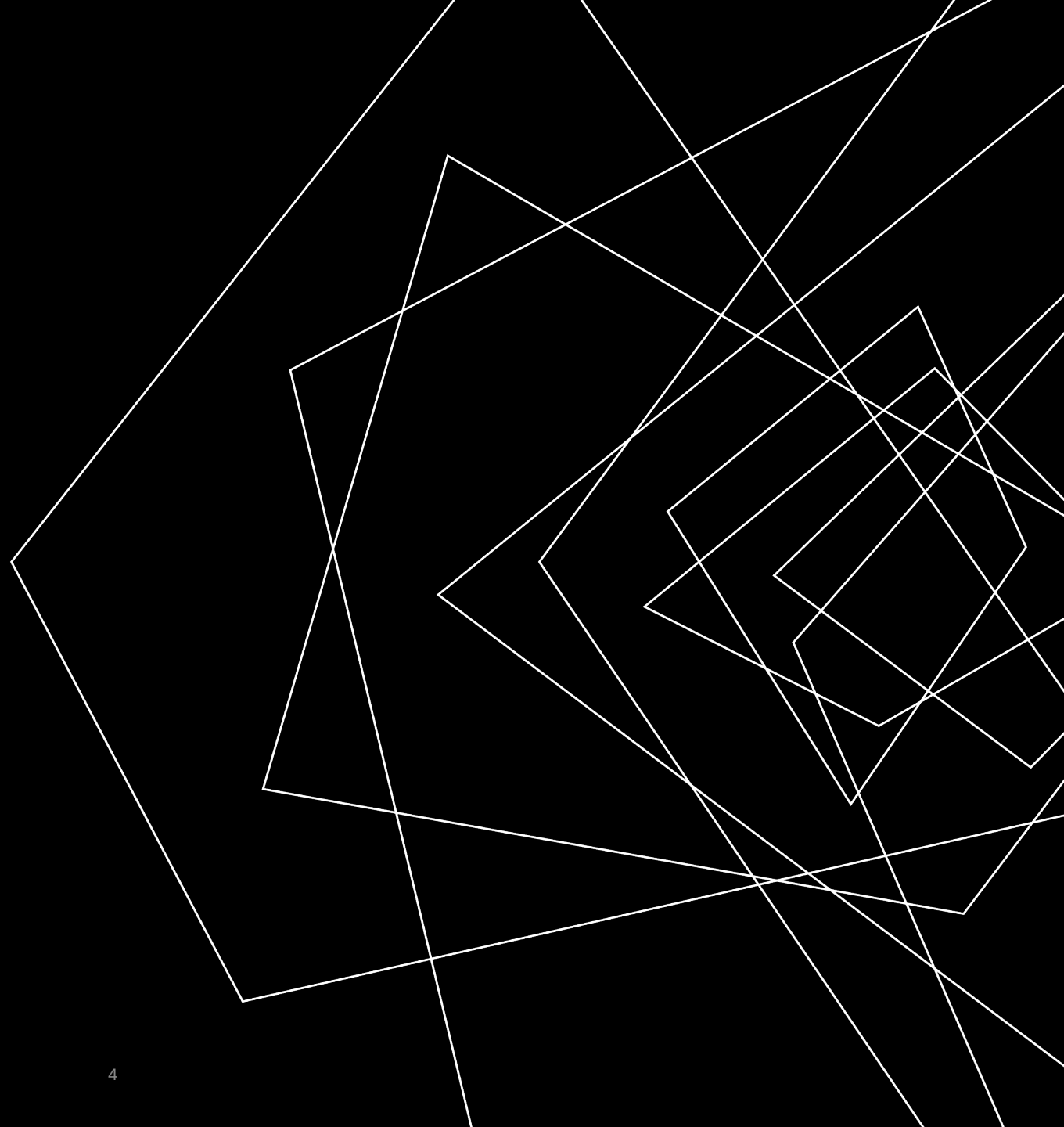
MOTIVATION

I once watched a Netflix documentary on the solar system. It said that the sun’s surface temperature was about 5600 degrees Celsius. Knowing that the temperature of boiling water is 100 degrees Celsius, I wondered how we could live peacefully on Earth without being scorched by the sun. I did this experiment to see how light intensity decreases with distance, using available light sources. If light propagation in space is understood, we could use that knowledge to estimate the distance between other celestial objects and Earth.



PROBLEM

How does the light intensity of different sources decrease with distance?

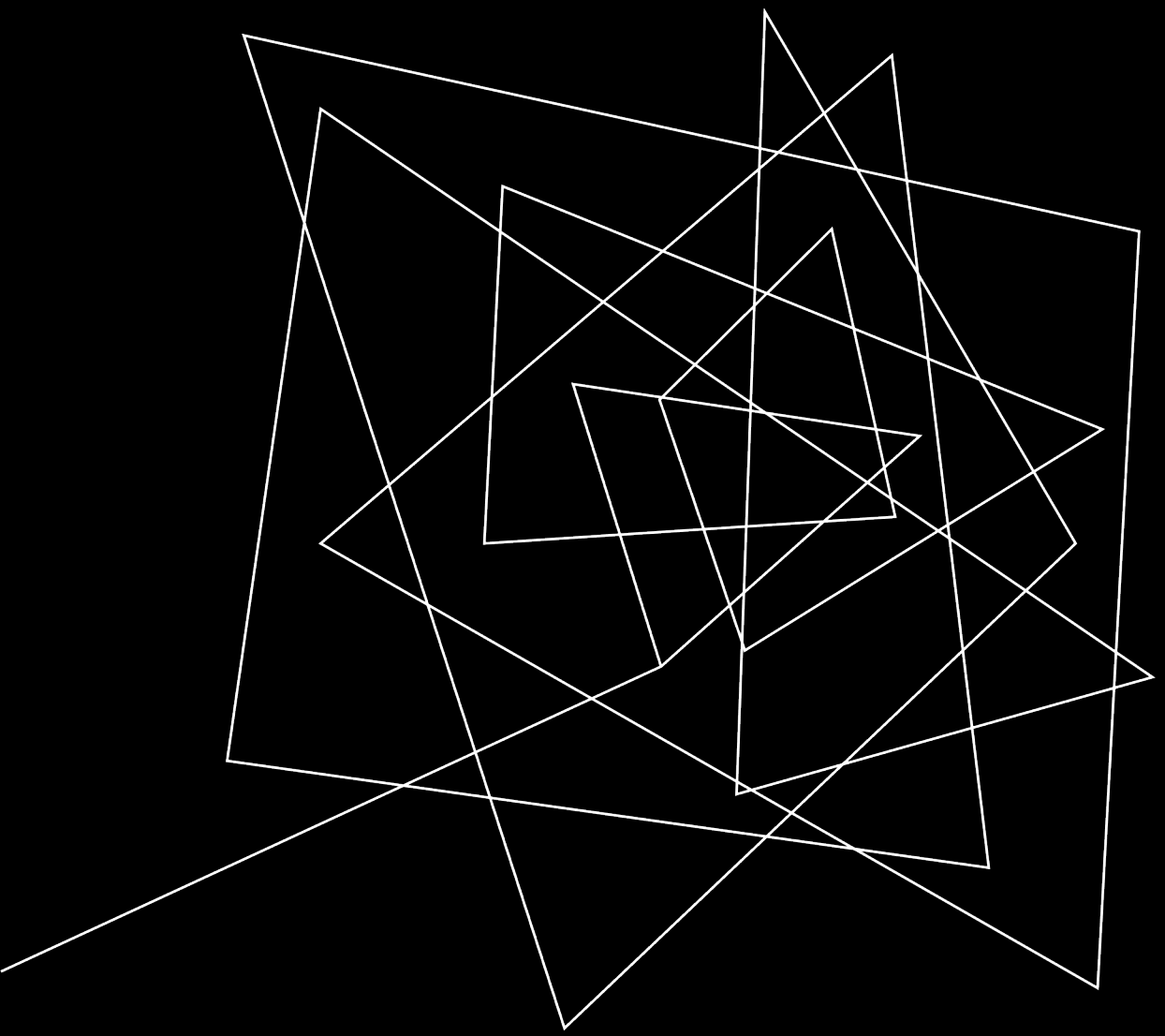


BACKGROUND

Visible light is the small portion of the electromagnetic spectrum between ultraviolet waves (UV waves) and infrared waves (heat waves) (Engineering para. 2). Different wavelengths of light are interpreted by the human eye as the different colors, such as red, orange, yellow, green, blue, and violet (Engineering para. 3). Artificial light (any man-made light) only emits some wavelengths of light (EarthSky para. 2). The sun emits all the colors of the spectrum which produces white light, and radiates much more energy than any light bulb (EarthSky para. 2). In fact, the sun is so powerful that its surface temperature is 5,600 degrees Celsius (Astronomer para. 1). To put this into perspective, the temperature of boiling water is 100 degrees Celsius. The fact that living creatures on Earth are not burned by the sunlight indicates that the light intensity must have decreased with the distance. In this experiment, I will investigate how light intensity varies with distance using a number of different light sources.

BACKGROUND (CONTINUED)

Light is measured in lumens and lux (Admin para. 2) (Divilife para. 8). Lumens are the unit of measurement for the amount of light emitted from an energy source (Admin para. 2). Lux is the unit of measurement for the number of lumens that land on a square meter (Divilife para. 8). The bigger the space that needs to be lit up, the less light falls on a surface, which is light intensity (Light Intensity para. 1). With most light sources, the amount of lux will decrease with distance because the farther something is, the more the light disperses, therefore decreasing the lux reading (Staff). **In this project, the light intensities of a candle, a light bulb, and a diode laser will be measured at different distances by a lux meter app.**



HYPOTHESIS

1. If the distance between the light source and the detector is increased, then the light intensity will decrease.
2. The light intensity of the laser will decrease the slowest, among the candle and the light bulb.

VARIABLES AND CONSTANTS

Independent variable: distance

Dependent variable: brightness of light

Control: light intensity from a point source follows the inverse square law

Constants:

- Darkness/brightness of the room
- Lux meter
- Direction the light is being pointed at from replicate to replicate
- Temperature of the room
- Procedures performed in the same room

MATERIALS AND RISK ANALYSIS

You will need:

- A light bulb
- A candle lamp
- A diode laser
- A lux meter
- A meter stick/measuring tape

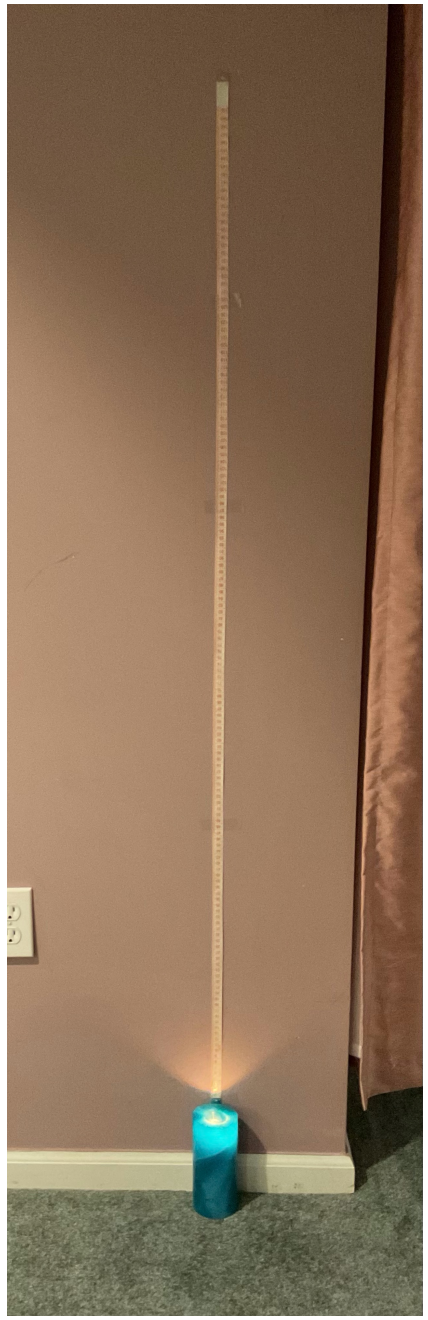
WARNING

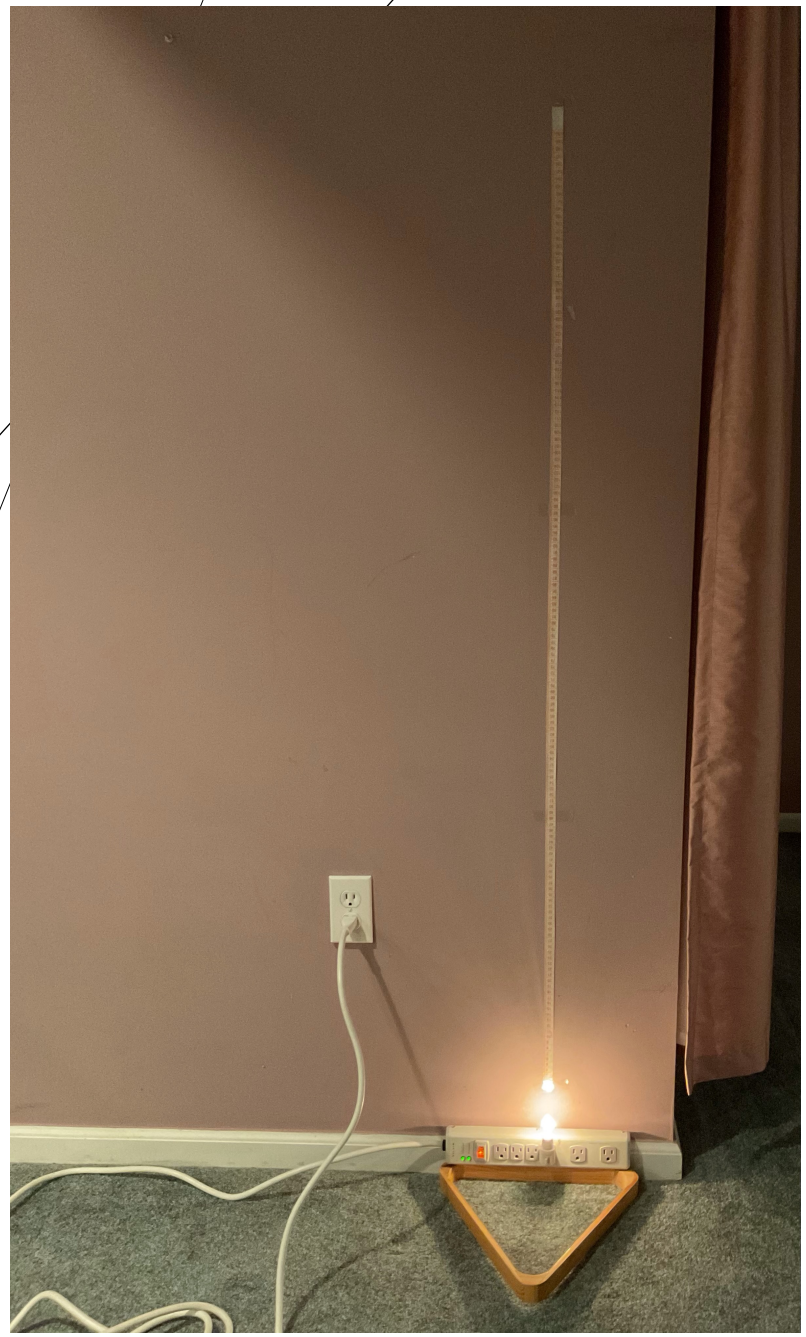
Do not shine the light in someone's face/eyes, especially the laser. It may lead to blindness or permanent damage to the eye.

Be careful when handling the candle. You might burn yourself with the wax.

PROCEDURE

1. Place the candle on a flat surface, keeping it in place and making sure the light faces up.
2. Place the detector at 5 centimeters above the light source, facing the candle.
3. Get a lux measurement.
4. Repeat steps 2 and 3 two more times. These are the replicates of the experiment.
5. Do steps 2 through 4 at the 10, 15, 20, 25, and 30 centimeter distances.





PROCEDURE (CONTINUED)

6. Place the light bulb on a flat surface, keeping it in place and making sure the light faces up.

7. Place the detector at 5 cm above the light, facing the light bulb.

8. Get a lux measurement.

9. Repeat steps 7 and 8 two more times. These are the replicates of the experiment.

10. Do steps 7 through 9 at the 10, 15, 20, 25, 30, 40, 60, 80, 100, and 120 centimeter distances.

PROCEDURE (CONTINUED)

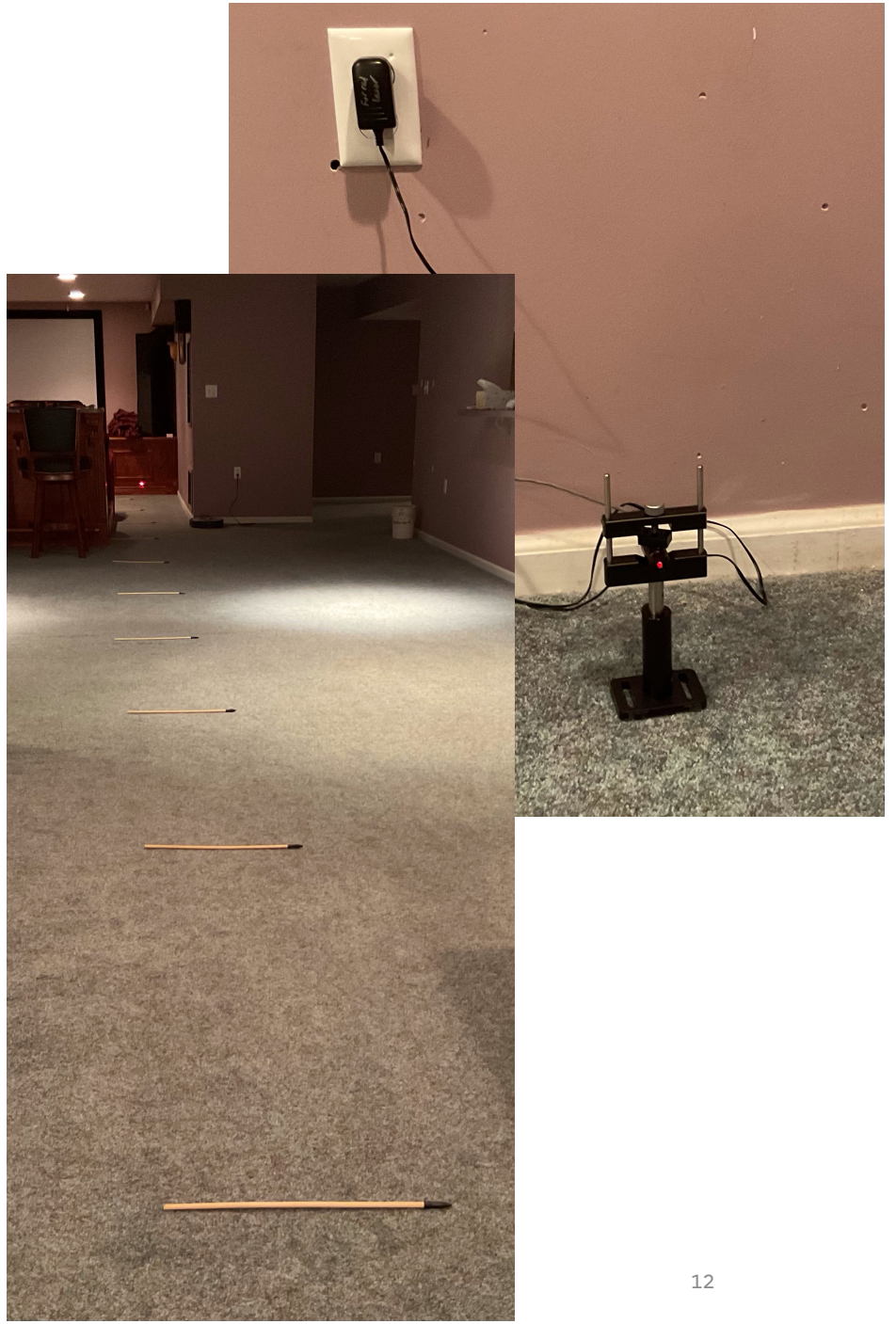
11. Place the laser on a flat surface, keeping it in place and making sure the light points horizontally.

12. Place the detector at 1.5 meters from the laser. The lux detector should be at the same height as the laser.

13. Get a lux measurement.

14. Repeat steps 12 through 13 two more times. These are the replicates of the experiment.

15. Do steps 12 through 14 at 3, 4.5, 6, 7.5, 9, 10.5, 12, 13.5, and 15 meter distances.



DATA TABLES

Light Intensity of a Candle vs. Distance

Distance (cm)	Replicate 1	Replicate 2	Replicate 3	Mean (lux)
5	185	234	234	217.666
10	52	52	52	52
15	15	15	15	15
20	10	15	15	13.333
25	3	3	7	4.333
30	1	3	3	2.333

DATA TABLES (CONTINUED)

Light Intensity of a Light Bulb vs. Distance

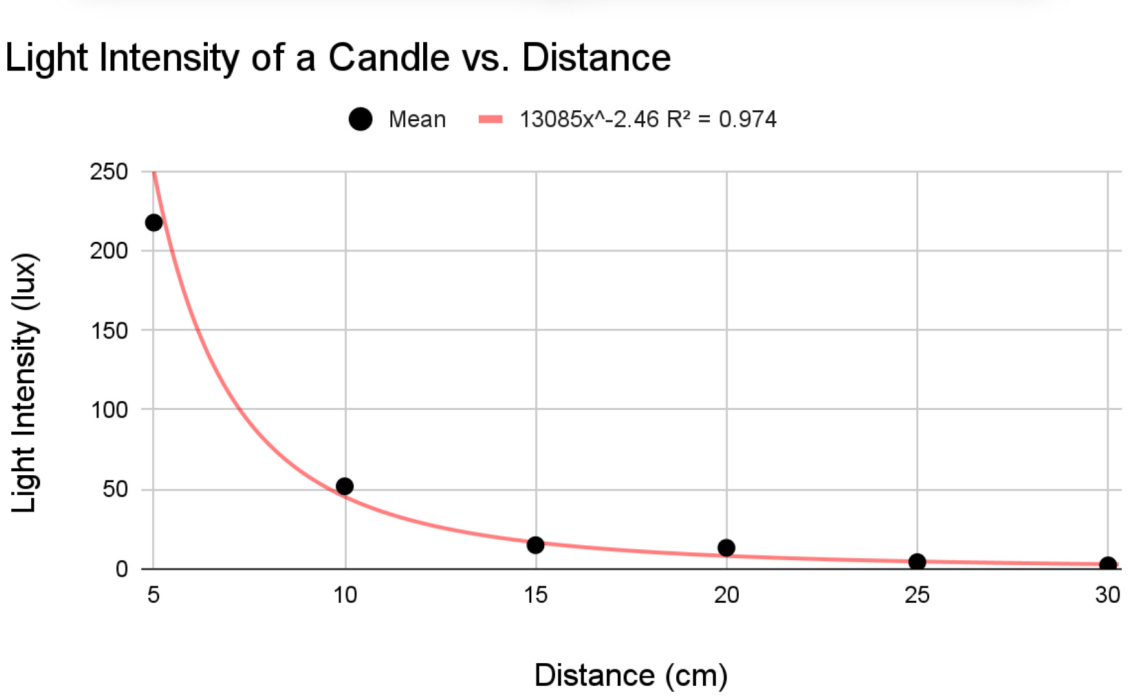
Distance (cm)	Replicate 1	Replicate 2	Replicate 3	Mean (lux)
5	963	963	963	963
10	396	396	396	396
15	234	234	234	234
20	185	185	185	185
25	143	143	143	143
30	88	88	88	88
40	30	30	30	30
60	10	10	10	10
80	7	7	7	7
100	3	3	3	3
120	1	1	1	1

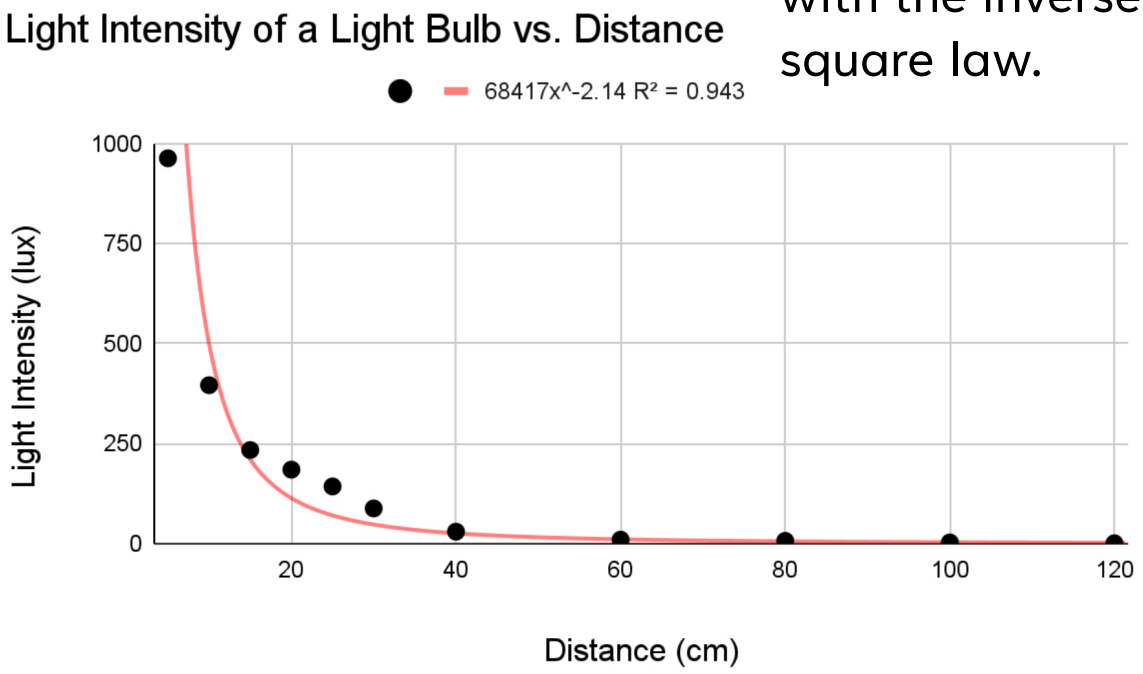
DATA TABLES (CONTINUED)

Light Intensity of the Laser vs. Distance

Distance (m)	Replicate 1	Replicate 2	Replicate 3	Mean (lux)
1.5	56,559	52,722	52,722	54,001
3	35,641	34,082	28,999	32,907.333
4.5	16,242	14,703	14,703	15,216
6	7929	7544	8273	7915.333
7.5	5712	5205	5388	5435
9	1540	1530	1874	1648
10.5	1206	1368	1226	1266.666
12	769	963	769	833.666
13.5	295	234	386	305
15	143	122	122	129

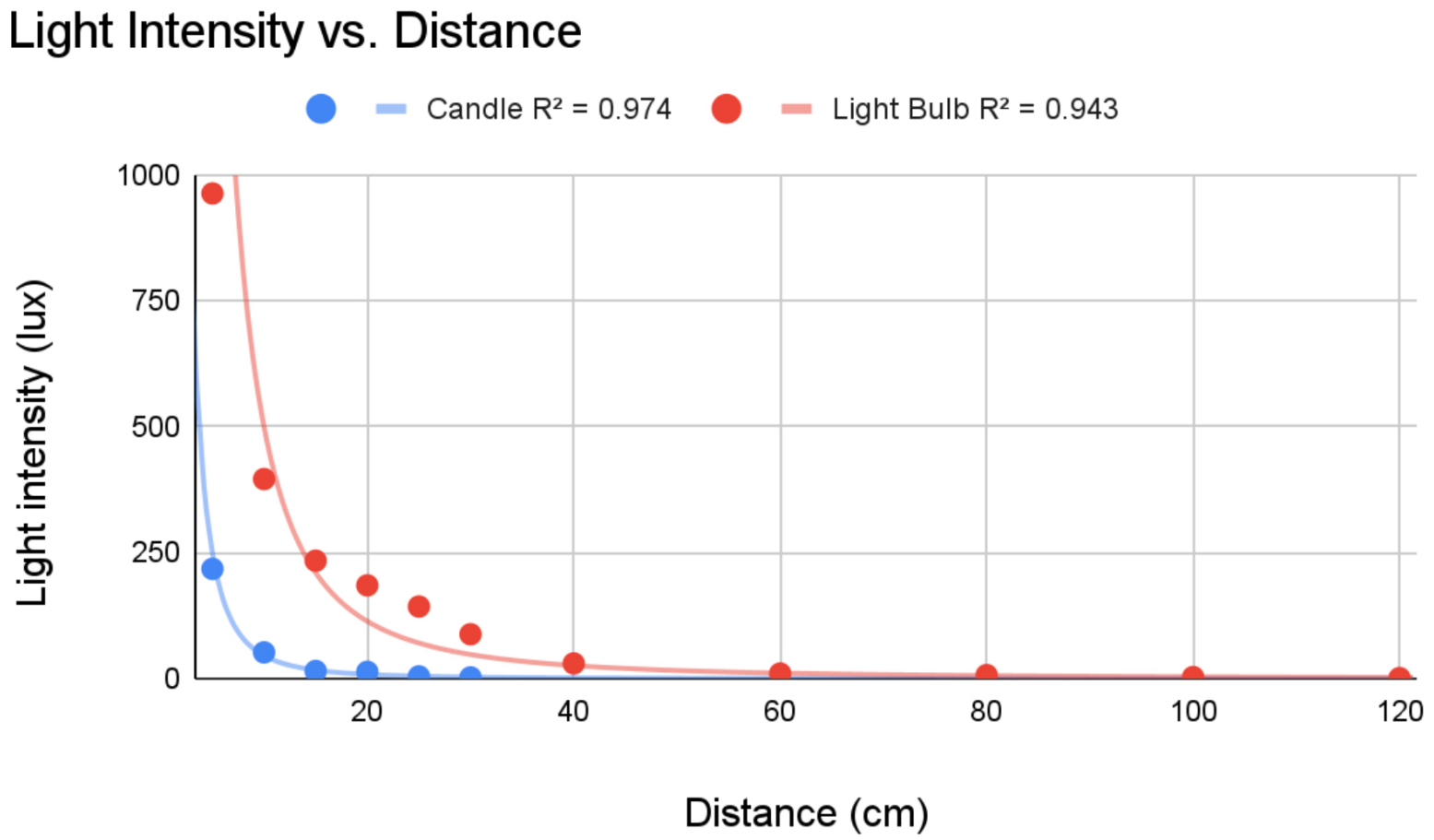
GRAPHS





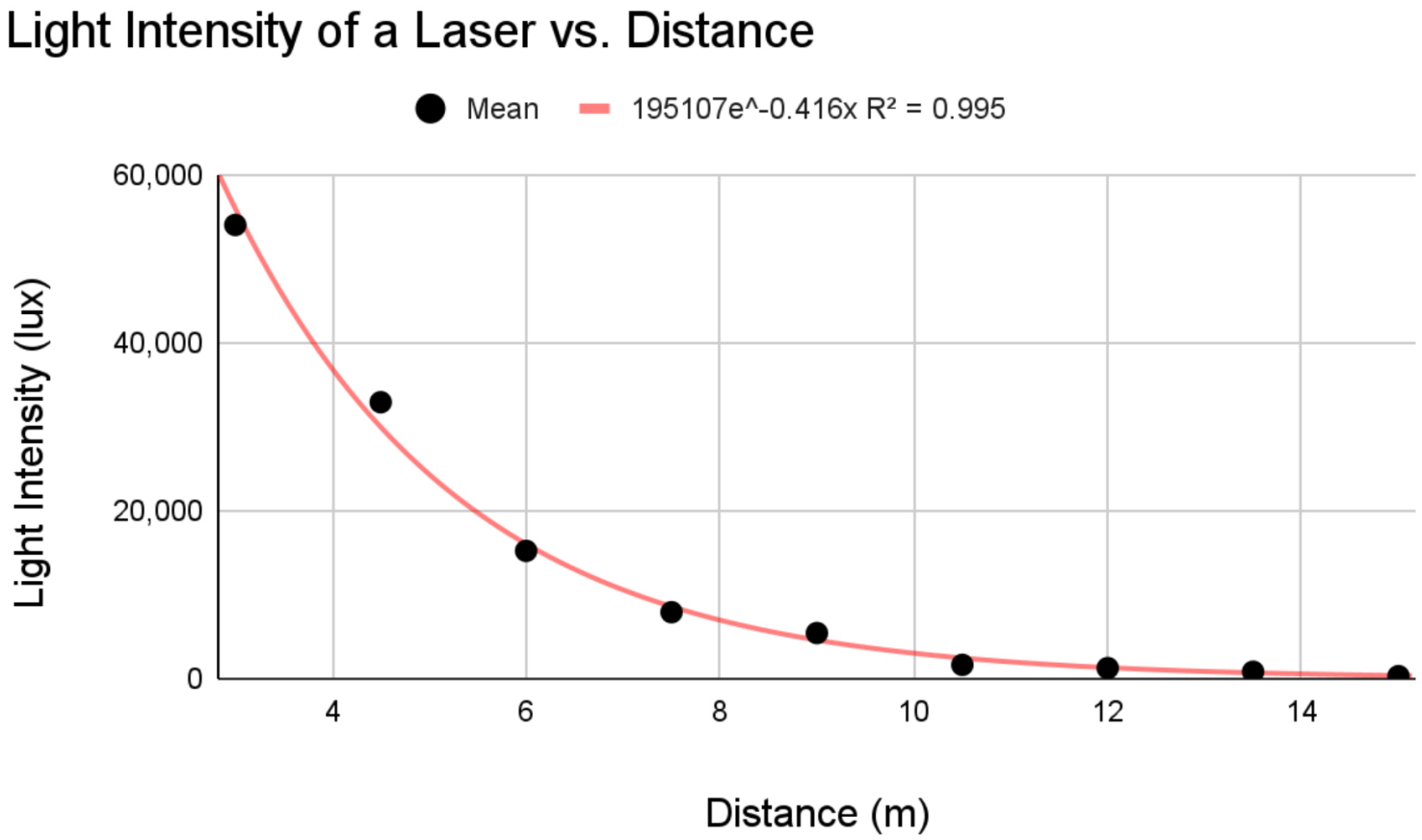
The measurement for the light bulb almost agrees with the inverse square law.

LIGHT BULB VS. CANDLE



The candle light decreased faster than the light bulb.

LASER



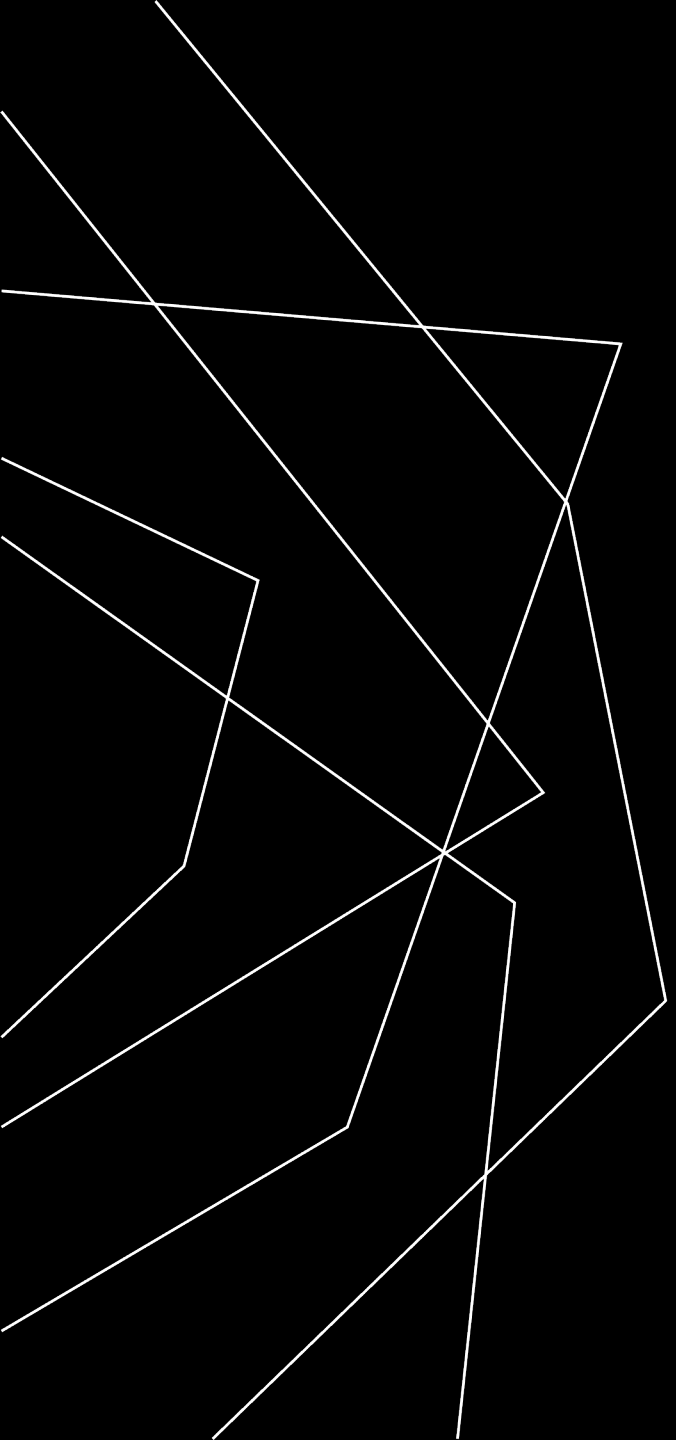
1. The light intensity of the laser dropped to 50 percent as the distance increased by approximately 2m.
2. The light intensity of the candle decreased halfway as the distance increased by about 2cm.
3. The light intensity of the light bulb decreased halfway as the distance increased by about 5cm.

CONCLUSION

1. The light bulb behaved similarly to a point source, as its intensity approximately decreased by the inverse square law.
2. The light intensity from all the sources decreased with distance. Specifically, the light intensity dropped to 50% as the distance increased by 2cm, 5cm, and 2m, respectively, for the cases of the candle, light bulb, and laser.
3. The hypothesis that the laser would decrease the slowest is accepted. The reason for the laser decreasing the slowest is that it points all its energy in only one direction, whereas the light bulb and the candle radiated its energy in all directions.

ERROR ANALYSIS

A systematic error with the experiment was the low quality of the lux detector, being merely an app on a phone. This experiment would be improved by using a better quality lux detector. Also, the angle the light source was pointed at the camera may have changed from replicate to replicate, changing the measurements. Paying more attention to the angle of the camera is a way to reduce this error. More trials and replicates would also improve precision of the measurements.



THANK YOU

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Photos taken by entrant