Experiment P-41
Light and Shadow

Physics

Objectives

- To understand the principles of light and shadow.
- To measure the intensity of light at the unblocked region, the penumbra region (partly blocked), and the umbra region (fully blocked).
- To investigate different parameters affecting a casted shadow.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- NUL-204 Light logger sensor

Equipment and Accessories

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▪	Table lamp	1
▪	Fluorescent bulb	1
▪	Black paper	2
▪	Ruler	1
▪	Sellotape	1
▪	Thin carton box	1

- The items above are included in the NeuLog Light kit, LGT-KIT.

Introduction

Light travels in straight lines from its source. When it is projected on an object (which does not transmit light), it is either absorbed or reflected by it. Therefore, we see a shadow, which is an area with less light than its surrounding.

The shadow is affected by many parameters: the distance between the light source and the object, the distance of the screen from the object, the size of the object, the size of the light source, and the angle between the light source and the screen.

A point source of light is either relatively very small or alternatively very far away. In this case, all the rays that strike the object come from a single point and therefore, a simple shadow is formed as shown in the figure below.
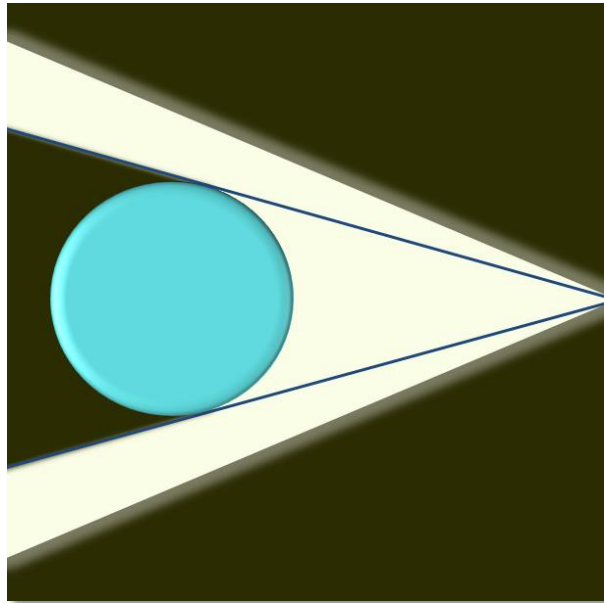
When the source is not a point source, two regions in the shadow are formed. The umbra is the region where all the light from the source is blocked by the object. The penumbra is a partial shadow around the umbra. It is formed because only part of the light is blocked by the object in this area.

The figure below shows the umbra and the penumbra parts of a shadow. Drawing lines from different parts of the light source to the penumbra and umbra regions may help you understand this concept.
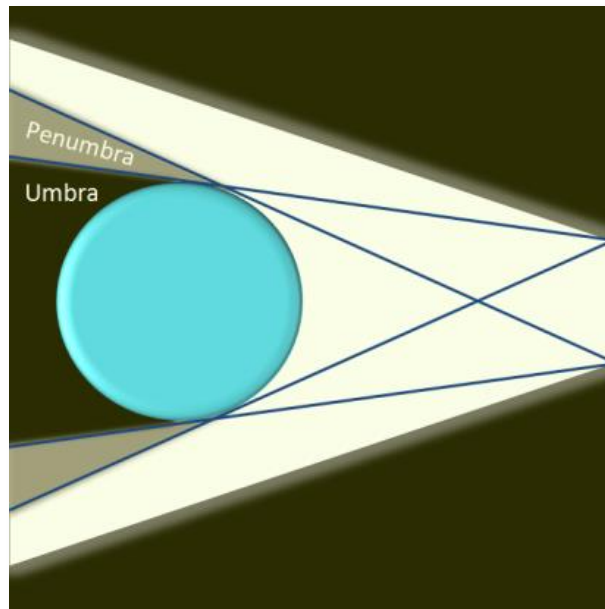
When the angle between the light source and the screen is smaller the casted shadow is larger.
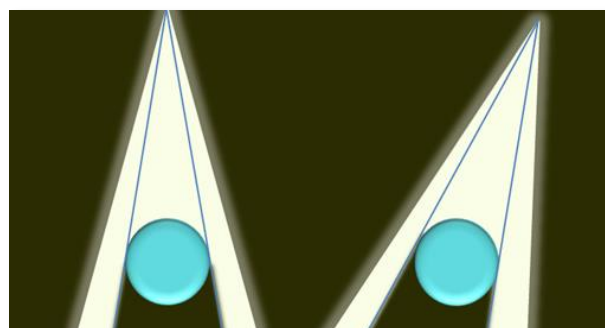

Light and shadows are integral features in art. They give a realistic look to painted objects. Therefore, an artist must be familiar with light and shadow principles.

In this experiment we will form a shadow using a lamp and a box. We will measure the light intensity in the unblocked region, the penumbra region (partially blocked) and the umbra region (fully blocked). We will also observe the shadow while changing different parameters such as the angle between the light source and the screen.

Procedure

Experiment setup

1.   Set up the experiment as shown in the picture below.
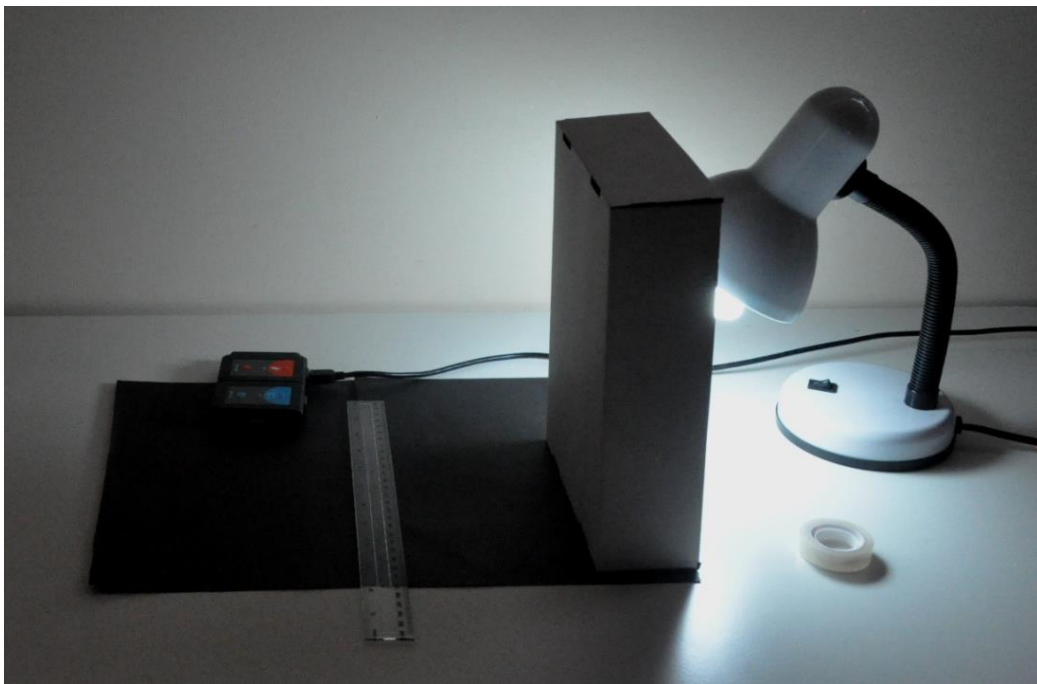
2.   Place two black papers on the table. Their purpose is to minimize reflectance from the table.

3.   Place the lamp next to the papers and a box in front of the lamp. The box should be taller than the light bulb.

4.   Turn on the lamp and dim the lights in the room.

5.   Move the box until you can see the umbra and penumbra regions very clearly. Make sure that the light bulb does not touch the box.

6.   Place a ruler on the casted shadow area (including the unblocked part).

7.   Put the light sensor (connected to the USB-200 module) on (or behind) the ruler, a few centimeters from the observed penumbra region. The sensor's opening should be directed towards the light source.

8.   If needed, tape the ruler to the papers, and the papers to the table.

Sensor setup

9.   Connect the USB-200 module ___ to the PC.

10.   Check that the light sensor ___ is connected to the USB-200 module.

Note:

The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

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11.   Run the NeuLog application and check that the light sensor is identified.

Settings

12. Click on the **Sensor's Module** box.

13. Select the "0-1000 lx" button to change the sensor's mode to the 0-1000 lx range.
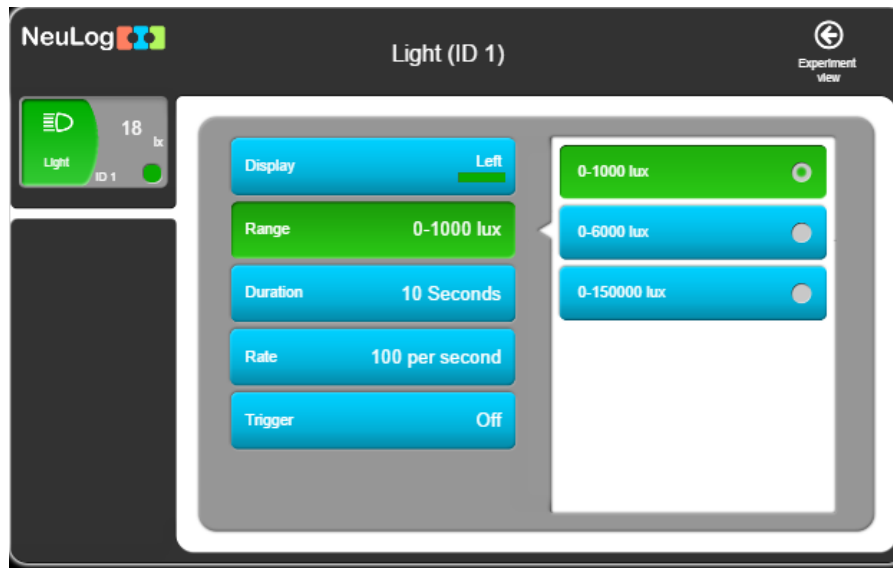
14. This experiment is done in single step mode so the experiment duration and sample rate will not be set.

Testing and measurements

15.   Before starting the measurements, turn off the lamp and check that the light intensity level displayed in the module window is lower than 60 lx.

16.   Turn on the lamp and click on the **Single Step** icon .

17.   Click on the **Table** icon on the bottom part of the screen. A table will be displayed for data record.

18.   Click on the **Manual values** icon .

19.   Insert "Light sensor's position" in the column name section.

20.   Insert "cm" in the units section.

21.   Insert the sensor's position according to the ruler in the "Light sensor position (cm)" column. You can fill in the rest of the column by adding 0.5 cm in each row (after every measurement).

22.   Move the sensor 0.5 cm towards the shadow and click again on the **Single step** icon .

23.   Proceed in this way until the sensor gets into the umbra region (make a few more measurements in this region).

24. Your data should be similar to the following:

Samples	Light sensor position (cm)	Light (0) ID 1, Exp 1
0	1	803
1	1.5	811
2	2	799
3	2.5	790
4	3	805
5	3.5	798
6	4	802
7	4.5	795
8	5	795
9	5.5	787
10	6	784

25. Click on the **Graph** icon [graph icon].

26. Click on the **Functions** icon [functions icon] and change the X axis to "Light sensor position".

27. Your graph should be similar to the following:
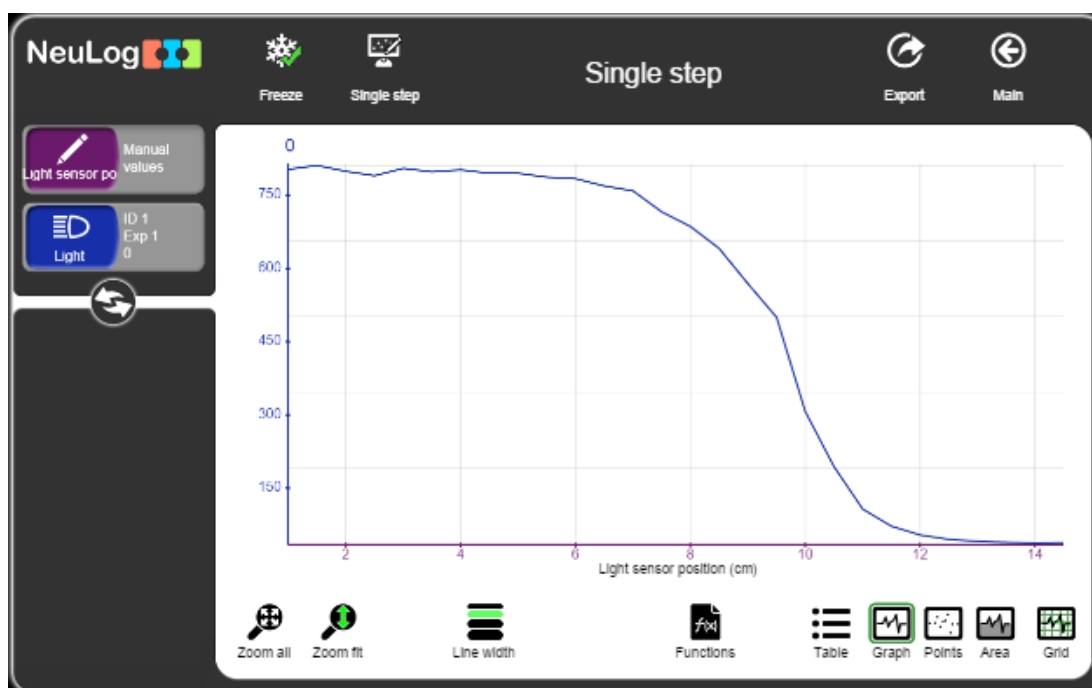
28. Click on the **Export** Icon and then on the **Save value table (.CSV)** button to save your graph.

29. Click on the icon to go back to the graph.

30. In the sample experiment, the measured value was around 800 lx while the sensor was in the unblocked region. As it entered into the penumbra region, light intensity started to decrease. When the sensor entered the umbra region it was fully blocked by the box and the light intensity stabilized on around 40 lx.

Challenge research

31. Move the box, the sensor, and the ruler further away from the lamp. Repeat the measurement (How will the graph change?).

32. Change different parameters (as in the introduction), such as the angle between the lamp and the screen, and observe the casted shadow. You can use the wall as a screen.

Summary questions

1. Explain how the graph changed after moving the box away from the lamp.

2. Describe how the casted shadow changed in section 30 and explain.

3. Draw a simple object (in any shape), a light source and a shadow according to the principles you have learned in this experiment.