



Experiment P-40 Colors of Light



Objectives

- To learn what happens to colored light, when it passes through color filters.
- To investigate the additive color theory.
- To observe a stereoscopic image.

Modules and Sensors

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



Equipment and Accessories

▪ White light flashlight
▪ Blue light flashlight
▪ Green light flashlight
▪ Red light flashlight
▪ Colorless filter
▪ Blue filter
▪ Green filter
▪ Red filter
▪ Ruler
▪ Sellotape
▪ White paper

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

Introduction

In order to understand color concepts, it is first necessary to understand light concepts. Visible light waves are seen by the human eye as different colors and they are characterized by their wavelength, which is the distance between any two corresponding points on successive waves. The length of the wave determines the amount of energy it has; the shorter the wavelength, the higher the energy.

Color may also be defined in more subjective terms, as something perceived by an individual. When light is reflected from an object, cones and rods in the retina of the eye respond to the light and the brain interprets the information received as color.

Light can be directly absorbed by an object, reflected at the surface or transmitted through it. The electromagnetic spectrum which is visible to us is in the range of 400-700 nm. When visible light with an energy distribution similar to sunlight (light of all colors) completely reflects from an object, this light appears white to the human eye. When the object completely absorbs all the light, it is recognized as black.

The primary colors of pigments (or dyes) are red, blue and yellow. Mixing these colors creates secondary colors. The primary colors of light are red, blue and green (corresponding to the three types of cones in our retina). Mixing colors of pigments produces different outcomes than mixing colors of light.

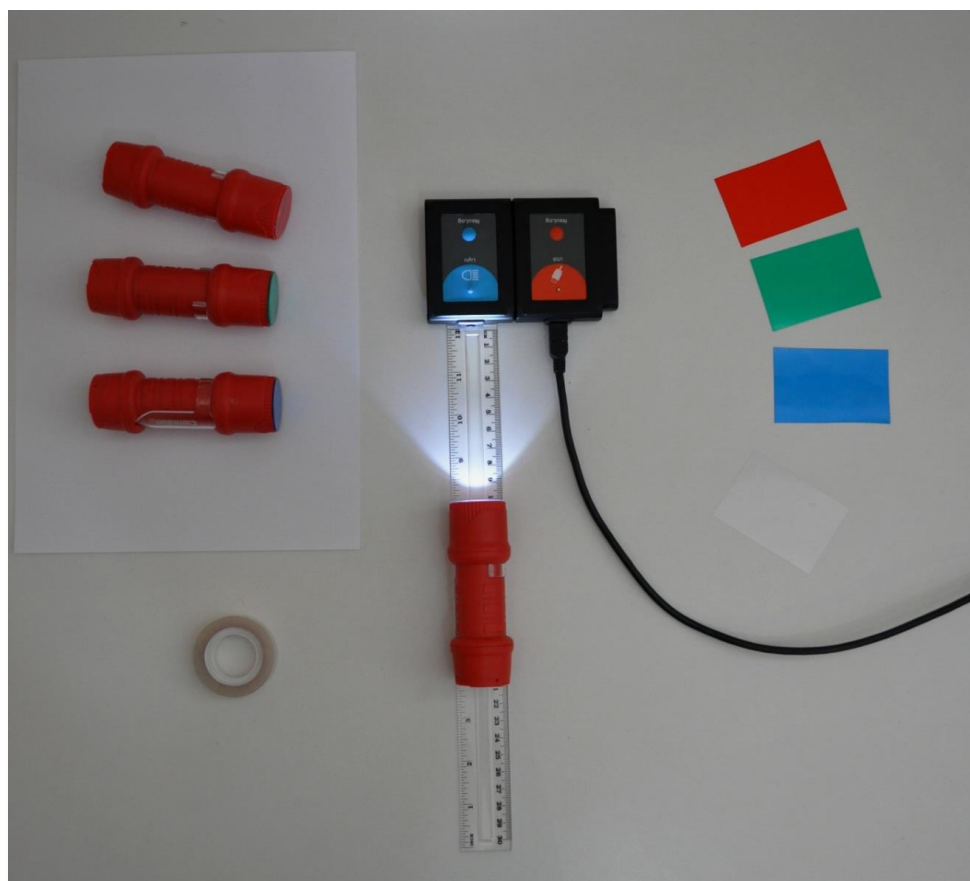
An opaque object that appears blue reflects mostly blue light (wavelength of around 450-495nm) and absorbs the rest of the light. However, when we project light through a color filter, some light is absorbed and some is reflected and transmitted. A red filter transmits (and reflects) mostly red light and absorbs the rest. Filters are not perfect and a small amount of the red light will be absorbed, also a small amount of other colors will be transmitted.

In this experiment, you will measure the intensity of white, blue, green and red light before and after it is transmitted through a color filter. You will mix light of different colors according to the color additive theory and observe the new colors produced. You will also use color filters to look at a stereoscopic image and learn how the formed image is created.

Procedure



Experiment setup

1. Set up the experiment as shown in the picture below.



2. Place a ruler in front of the light sensor opening.
3. Place the white light flashlight 10 cm from the sensor.
4. If needed, use the sellotape in order to tape the flashlight to the table.
5. Dim the light in the room.
6. Turn on the flashlight and make sure that the beam is directed towards the sensor's opening.

Sensor setup


7. Connect the USB-200 module  to the PC.
8. 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.

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




Settings

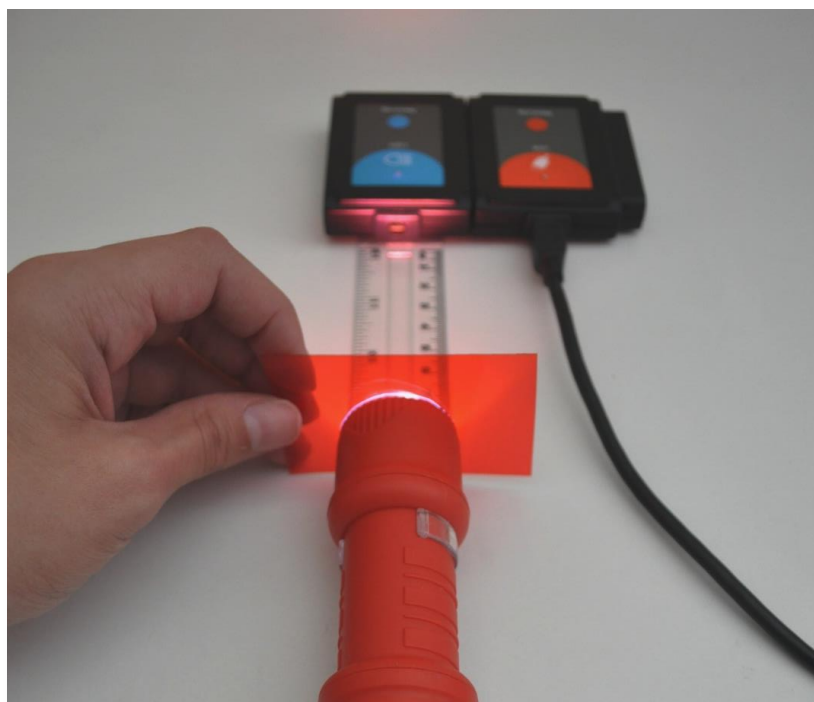
10. Click on the **On-line Experiment** icon  in the NeuLog main icon bar.
11. Click on the **Sensor's Module** box.
12. Click on the **Range** button.
13. Select the "6000 lx" button to change the sensor's mode to the 0-6000 lx range.



14. This experiment is done in single step mode so the experiment duration and sample rate will not be set.

Testing and measurements

15. Turn off the flashlight and make sure that the light intensity level displayed in the module window is lower than 60 lx.
16. Turn on the flashlight.
17. Place the colorless filter in front of the flashlight and click on the **Single Step** icon .
18. Click on the **Table** icon  on the bottom part of the screen. A table will be displayed for data record.
19. Change the manual values column name to "Flashlight and filter" (clicking on the title of the column will allow you to do so).
20. Insert the color of the flashlight's light and the filter ("white, colorless") in the "Flashlight and filter" column.
21. Instead of the colorless filter, place the red filter in front of the flashlight and click on the **Single Step** icon .




The red filter transmits red light and absorbs the rest of the light (some light is also reflected).

22. Insert the color of the flashlight's light and the filter ("white, red") into the "Flashlight and filter" column.
23. Repeat the measurements with the rest of the flashlights (with blue, green and red lights) as shown in the following table (If the intensity is significantly different among flashlights move the flashlight closer or further away from the light sensor):

Measurement number	Flashlight's light	Color of filter
1	White	Colorless
2	White	Red
3	Blue	Colorless
4	Blue	Red
5	Green	Colorless
6	Green	Red
7	Red	Colorless
8	Red	Red

24. Your data should be similar to the following:

Step	 Light (ID=1) [lx]	Flashlight and filter
Step 1	3523	White, colorless
Step 2	1044	White, red
Step 3	3048	Blue, colorless
Step 4	304	Blue, red
Step 5	3043	Green, colorless
Step 6	411	Green, red
Step 7	3514	Red, colorless
Step 8	2106	Red, red

25. We can see each time the red filter reduced the light intensity of the flashlights.

26. We will calculate the ratio between each flashlight's red filter value and colorless filter value.

Flashlight's light	Red filter value / colorless filter value
White	
Blue	
Green	
Red	

Challenge research

27. Repeat the experiment with a blue filter instead of the red one (think about the expected results).
28. Pick any flashlight and direct its light towards a white paper. Place one of the filters in front of the flashlight and observe the change in color. Write down the observed color.
29. Take two of the colored light flashlights. Direct their light to one spot on the white paper and observe the color of that spot. Write down the observed color.
30. Take the three colored light flashlights. Direct their light to one spot on the white paper and observe the color of that spot. Write down the observed color.

31. Take the red filter and place it in front of your left eye.
32. Take the blue (or green) filter and place it in front of your right eye.
33. Look at the image bellow (should be viewed in color):



What do you see?

Summary questions

1. Explain the results of the first and second experiments (with a red and a blue filter). What affects the ratio between the red filter values and the colorless filter values?
2. Explain your observations on sections 28-30.
3. Write an example of the use of additive colors.
4. Did you notice a change in the image while looking at it through the filters? What is the role of the red and cyan colors?