Experiment P-31
Light Absorption and Heat

Objectives

- To understand the concept of color.
- To demonstrate the effect of color on light absorption and the conversion of that light into heat, using black and white papers.
- To measure body surface temperature while being covered with black or white gloves.

Modules and Sensors

- PC + NeuLog application
- USB-200 module 
- Two NUL-233 Surface temperature logger sensors 

(It is also possible to conduct the experiment with one NUL-233 surface logger sensor by measuring sequentially.)

Equipment and Accessories

▪ Incandescent light bulb
▪ Table lamp
▪ Sellotape
▪ White paper (5 cm X 5 cm)
▪ Black paper (5 cm X 5 cm)
▪ White glove (or fabric)
▪ Black glove (or fabric)

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.

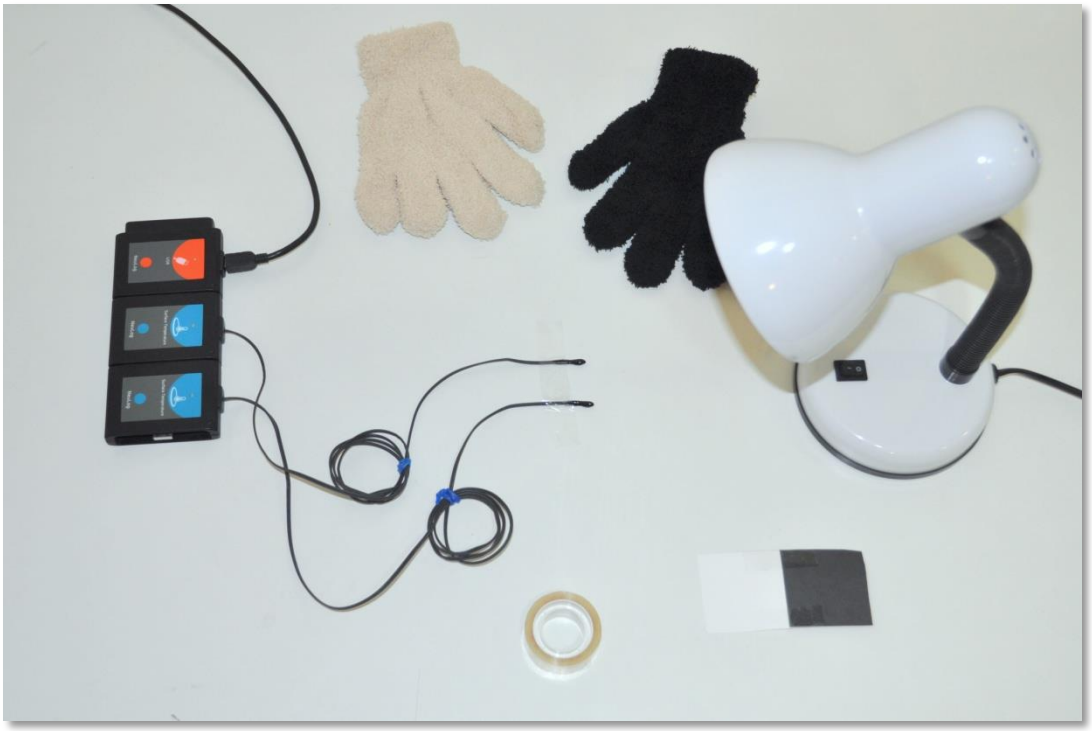
Light can be directly absorbed by an object, reflected at the surface or transmitted through it. The electromagnetic spectrum which is visible to us is in the range of 400-700 nm. When visible light with an energy distribution similar to sunlight (light of all colors) completely reflects from an object,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

In the following experiment, we will irradiate black and white papers; we will measure the temperature beneath them in order to observe the effect of color on energy absorption. We will also use gloves or fabrics to see if the body surface temperature is affected by their color.

Procedure

Experiment setup

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



2. Tape the two surface temperature probes on the table with a distance of about two cm between them.

3. Make sure you have a lamp with the bulb positioned 20 cm higher than the probes.

Sensor setup

4. Connect the USB-200 module  to the PC.

5. Check that the two surface temperature sensors  are connected to the USB-200 module in a chain.

Note:

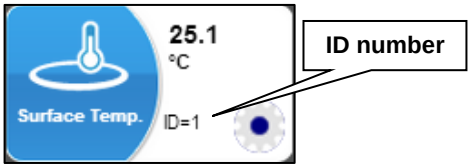
The following application functions are explained in short. It is recommended to practice the NeuLog application functions (as described in the user manual) beforehand.

6. Run the NeuLog application and check that the two surface temperature sensors are identified.

ID numbers setup:

In order to use two sensors of the same kind, they should have different ID numbers.

- Connect one of the sensors and check that it is identified.
- Click on the **Tools** icon in the main icon bar.
- Click on the **Set sensors' ID** button and click on '2'.
- The sensor will change its ID to 2.
- The **Search** function will run automatically and you will see that the sensor's module box now shows '2'.



- Disconnect the sensor with ID number 2 and connect the next sensor in order to change its ID. Proceed as you did for the first sensor.
- Repeat this procedure for any other sensor of the same kind you want to connect in a chain.
- Once your sensors (in this case two surface temperature sensors) have different ID numbers, you can connect them in a chain.

Settings

7. Click on the **On-line Experiment** icon in the NeuLog main icon bar.

8. Click on the **Experiment setup** icon and set the:

   Experiment duration to 5 minutes
   Sampling rate to 60 per minute

Testing and measurements

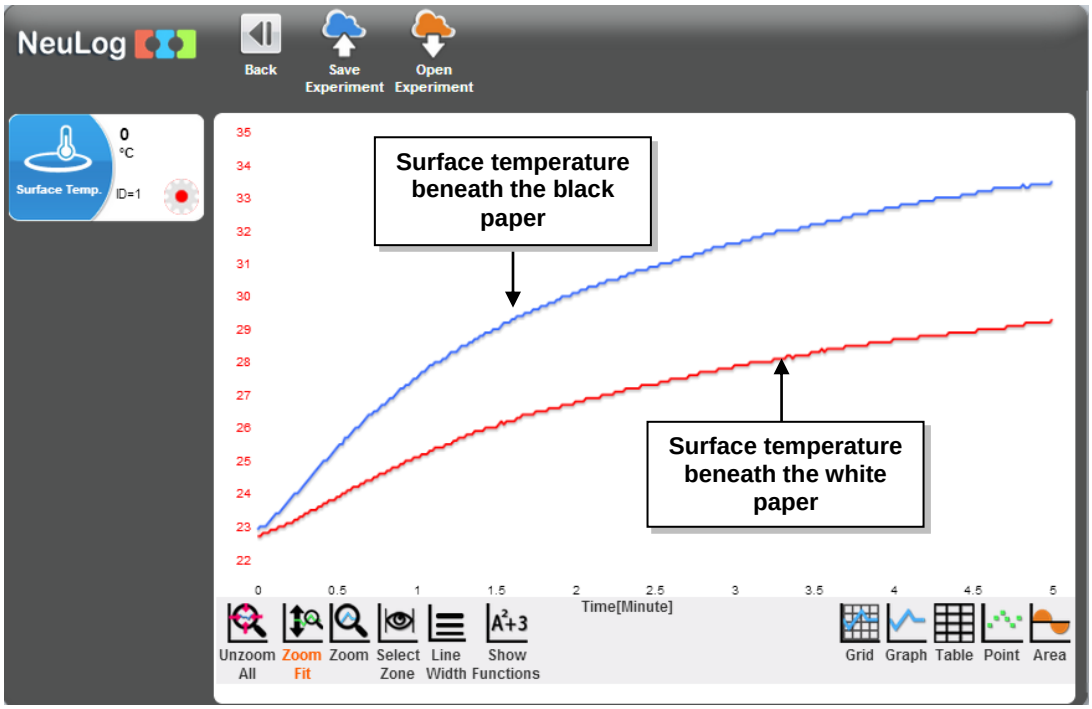
9. Cover each probe with a different colored paper.

10. Turn on the lamp.

11. Click on the **Run Experiment** icon to start the measurement.

12. In order to focus on the desired range, locate the mouse cursor at a point above the graph and press its left button; keep it pressed and create a rectangle that includes the whole graph.

13. Your graph should be similar to the following:



14. Save your graph.

15. We can see that the black paper absorbed more light than the white paper, this light transferred to heat which could be sensed by the surface temperature logger sensor.

16. Turn off the lamp.

17. Click on the **Show Functions** icon  , and then click on the surface temperature button on the left of the screen. You will see the minimum and maximum values.

18. Repeat this process for the second sensor by selecting 'Surface T. 2'

19. Fill the table with the minimum and maximum surface temperature values you have recieved.

20. Calculate the ΔT by subtracting the minimum temperature value from the maximum temperature value. Fill the table with the ΔT value.

Color of paper	Minimum temperature [^{o}C]	Maximum temperature [^{o}C]	ΔT [^{o}C]
White			
Black			

Challenge research

21. Tape a surface temperature sensor to each palm of your hands.

22. Put on a white glove on one of your hands and a black one on the other hand.

23. Turn on the lamp and repeat the measurement while putting your hands on the table next to the lamp. In this measurement you will observe the way cloth affects body heat.

Summary questions

1. After this experiment, which colors would you prefer to wear in the winter and which colors would you wear in the summer? Explain.

2. How can we measure the reflected light in the experiments?

3. A species of squirrels which displays brown, grey or black pelage color was studied. Black squirrels showed thinner body hair than other squirrels. Try to explain this observation.