Experiment E-6
Rayleigh Scattering

*Environmental*
Science

Objectives

- To learn about Rayleigh scattering and how it affects the color of the sky.
- To investigate visible, UVA, and UVB light throughout the day.

Modules and Sensors

- PC + NeuLog application
- USB-200 module
- BAT-200 Battery module
- VIEW-200 digital display module
- NUL-204 Light logger sensor
- NUL-230 UVB logger sensor
- NUL-232 UVA logger sensor

Introduction

Why is the sky blue? Lord Rayleigh, a British physicist, studied the way in which sunlight passes through our atmosphere and is scattered by gas molecules in the air. He found that blue light is much more easily scattered than red light. The reason is that the blue wavelength (around 400 nm) is closer to the size of the air molecules than the red wavelength (around 700 nm). He proved that the amount of scattering is inversely proportional to the fourth power of the wavelength. This is the reason why the sky away from the sun appears blue. Red or yellow are scattered a lot less and reach our eyes when looking at the sun.
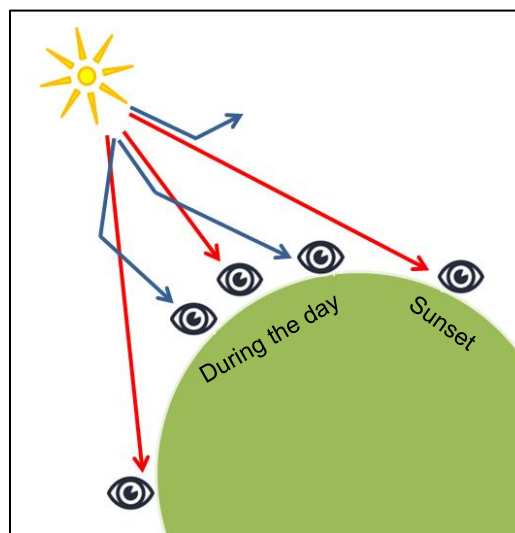
Why does the sky look yellow or red at sunrise and sunset? When the air is clear the sunset appears yellow. Light from the sun in different wavelengths pass a long distance through air, while blue light is scattered away. If the air contains small particles (natural or pollution) the sunset will look red.

Rayleigh scattering is also relevant to ultraviolet light (UV). UV light has a shorter wavelength than blue light and is scattered even more than blue light. UV rays are the main cause of damage to skin from the sun, therefore it is important to know in which hours they are more intense.

In this activity we will examine Rayleigh scattering by measuring visible light, UVA (400 – 315 nm), and UVB (315 – 280 nm) during the day.

Procedure

Experiment setup

1.   Connect the Light, UVA, and UVB sensors to the USB-
        module as shown in the picture below.

2.   Make sure you have a charged battery module and a digital
        display module. If you don't have a digital display module you
        can use a graphic display module or conduct the experiment
        without a viewer. You could also use a WiFi module with a
        tablet or a smartphone.

Sensor setup

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

4.   Check that the light , UVA , and UVB sensors are 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.
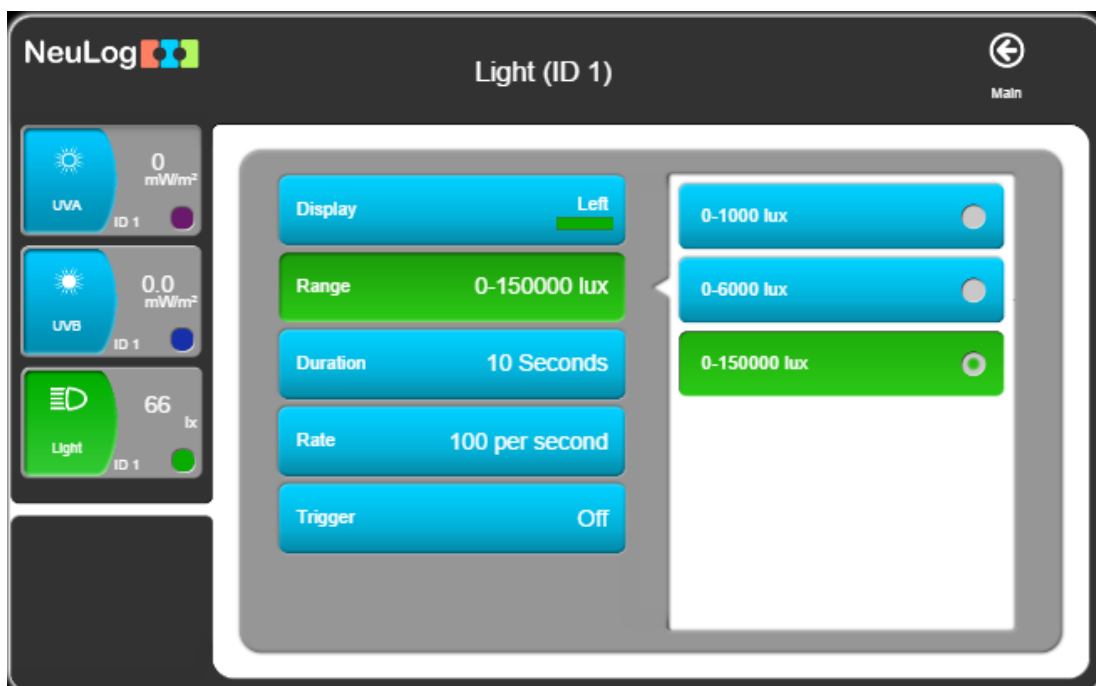
5.   Run the NeuLog application and check that the sensors are identified.

NeuLog

Settings

> Note:
>
> This experiment should begin in the morning and be conducted throughout the day. Samplings will be gathered every two hours.

6. Click on the light **Sensor's Module** box.

7. Select the **0-150,000** lux button to change the sensor's mode.

8. Set the:

    Experiment duration to 10 seconds
    Sampling rate to 50 per second

9. Click on the UVA **Sensor's Module** box and set the same parameters.

10. Click on the UVB **Sensor's Module** box and set the same parameters.

Testing and measurements

11.   Disconnect the sensors from the USB module.

12.   Connect the light, UVA, and UVB sensors to the battery module and the digital display module.


13.   If you do not see the light sensor's reading on the digital display module, press on the display module button a few times until you see the reading.

14.   Aim the sensors' opening toward the sun. Do not look straight at the sun.

15.   Direct the sensors to the point where the light sensor reading is maximal.

16.   Press on the sensors' (Light, UVA, UVB) start/stop buttons to start the measurement and wait until their LEDs shut off.

17.   Write down the time of the sampling.

18. Come back to the same place every two hours and repeat the measurement until you have 5 samplings. If there is a shadow in the place where you measured before, move to a place with more light.

19. At the end of the measurements, connect the sensors to the computer using the USB-200 module and wait until their modules appear on the left side of the screen.
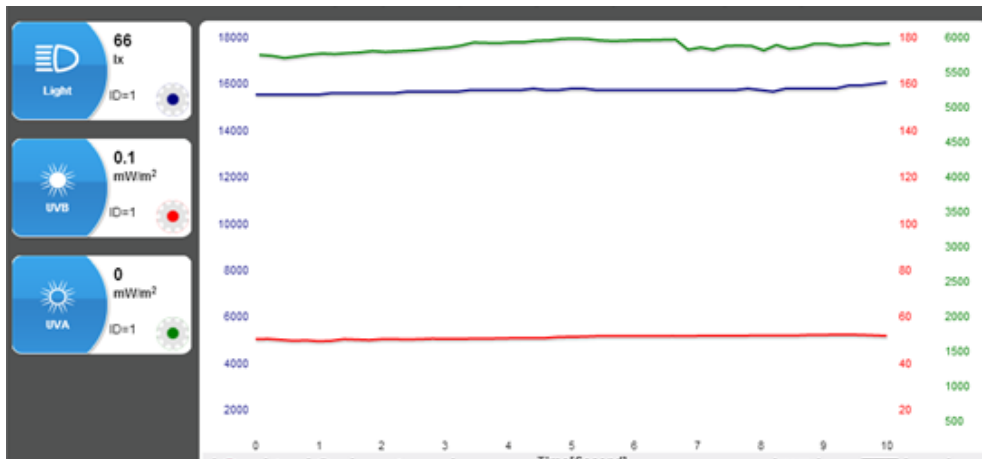
20. Click on the **Load Experiment** icon .

    The menu shows a list of experiments stored in the sensor's memory (up to 5).
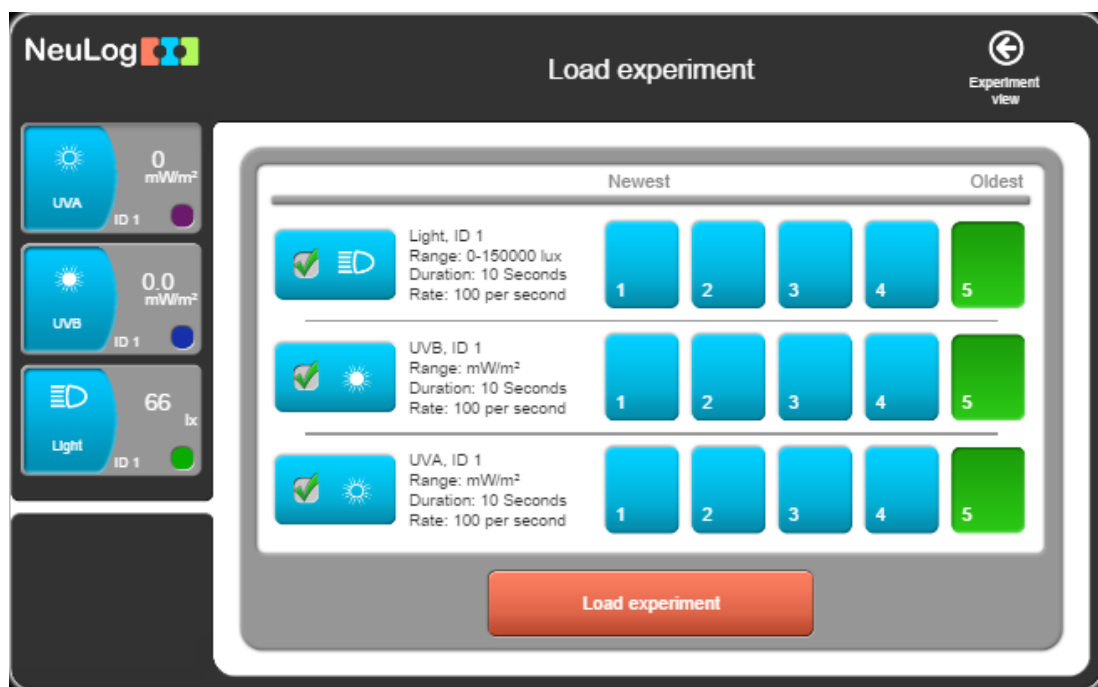
21. Choose the required experiment (in this case the 'Oldest') and click on the **Load Experiment** button.
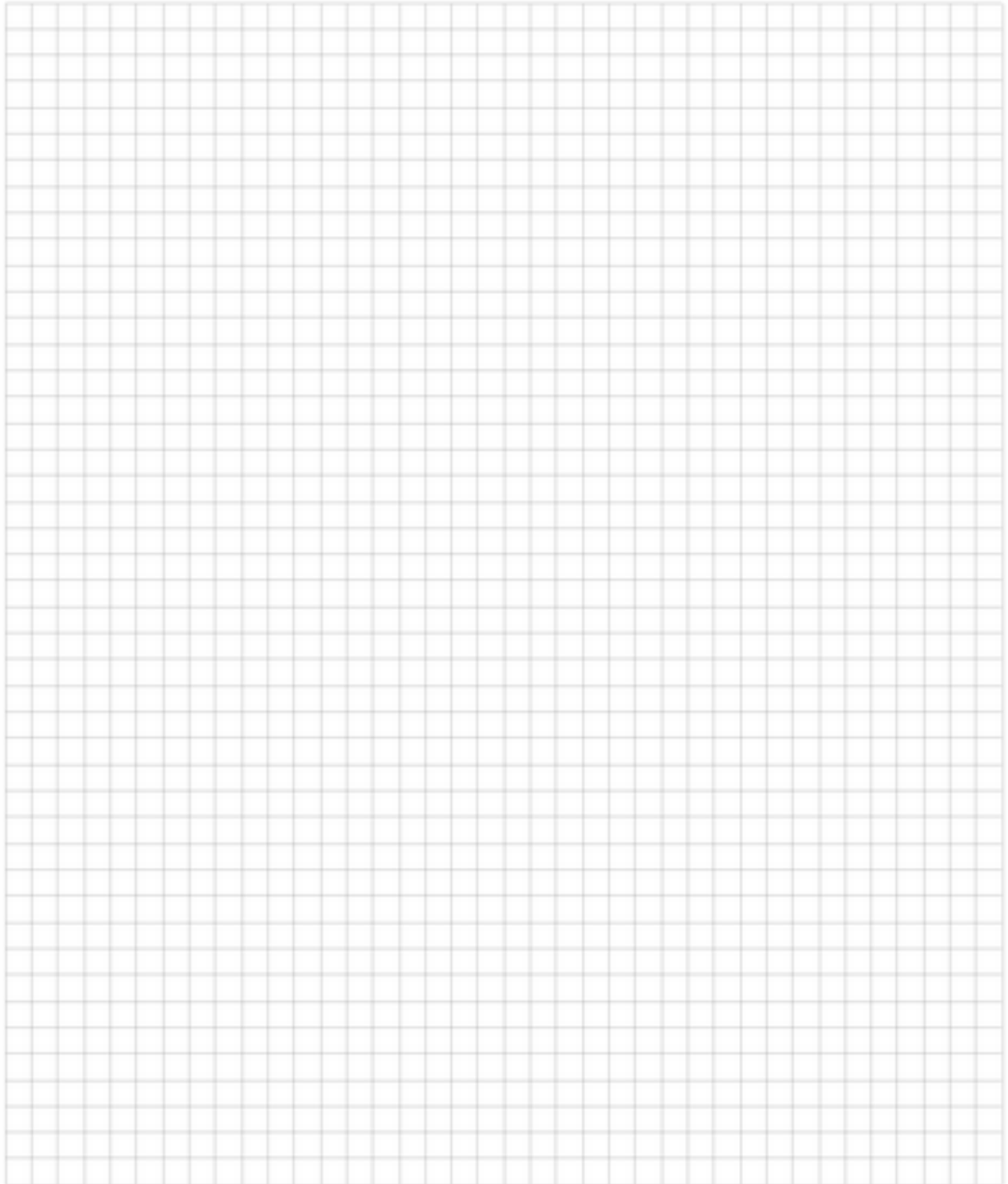
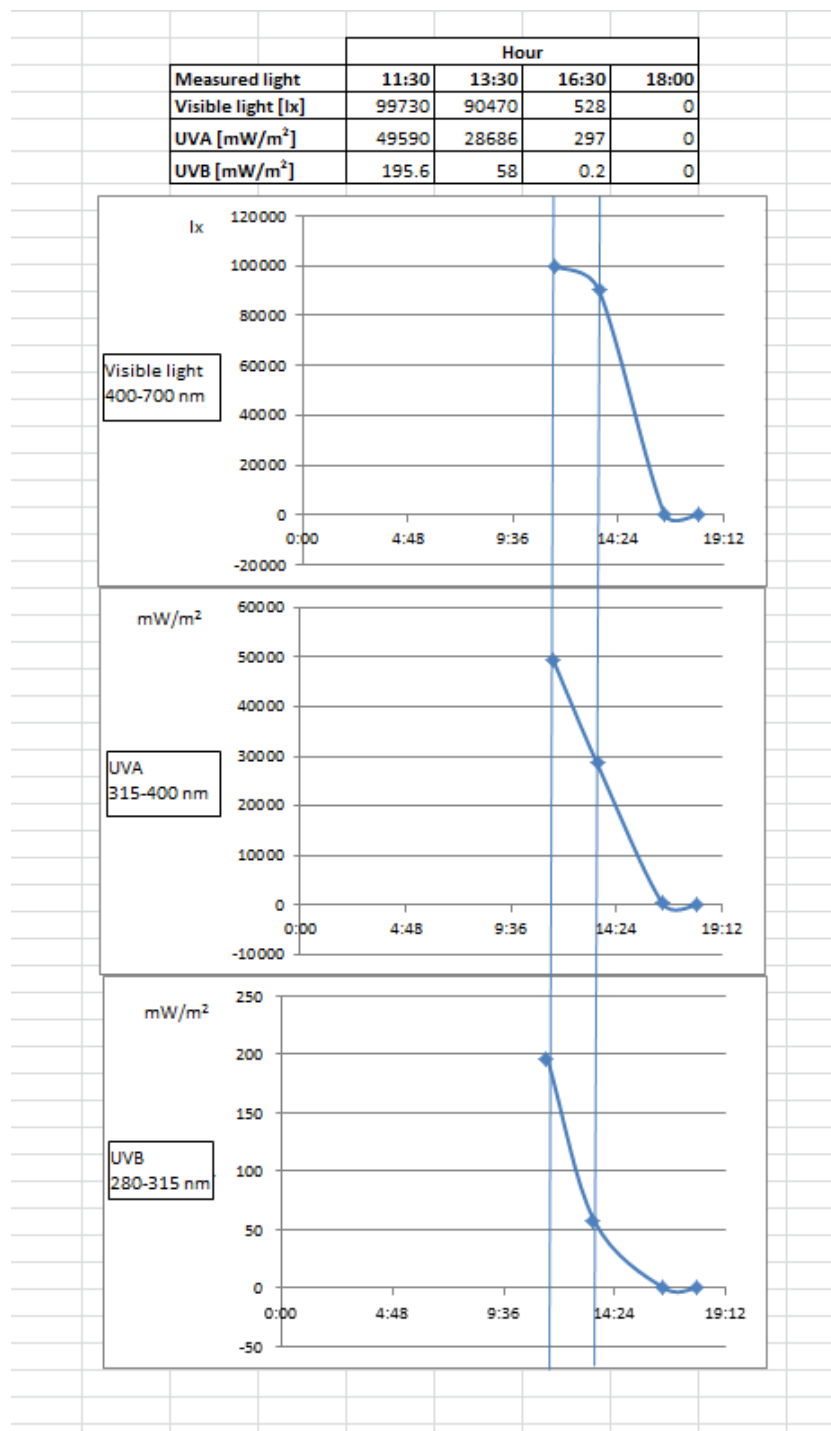22. Your graph should be similar to the following:

23. Save your graph.

24. Click on the **Light Sensor's** module box on the left of the screen.

25. Look at the **Highest sample value** value and fill in the table below.

26. Click on the **UVA Sensor's** module box on the left of the screen.

27. Look at the **Highest sample value** value and fill in the table below.

28. Click on the **UVB Sensor's** module box on the left of the screen.

29. Look at the **Highest sample value** value and fill in the table below.

	Time of day				
Sensor					
Light (visible) [lx]					
UVA [mW/m^2]					
UVB [mW/m^2]					

30. Load the rest of the measurements from the sensors (up to 5) and fill the table with the maximum values of each sensor.

31. Create graphs for each sensor by using Microsoft Excel or alternatively use this grid:

32. These are sample graphs plotted by Excel.

		Hour			
Measured light		11:30	13:30	16:30	18:00
Visible light [lx]		99730	90470	528	0
UVA [mW/m^2]		49590	28686	297	0
UVB [mW/m^2]		195.6	58	0.2	0

Summary questions

1. How did the visible, UVA, and UVB light change throughout the day?

2. Where there different patterns in the graphs?

3. Explain your results in terms of the Rayleigh scattering phenomenon.