



**Neuron Logger  
Sensor Network Technology**

# **User Guide**







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# Chapter 1 – Introduction

## 1.1 About data-loggers and sensors

In science experiments various values are measured, such as temperature, light, sound, voltage, current, distance, velocity, acceleration, oxygen percentage in air or in solution, pH etc.

Most of the measured values are analog, which change successively. The device that measures them is electronic so the value is changed into an electrical signal, and is called sensor or transducer. There is a specific sensor for each value.

The electrical signal is then converted into digital form in order to be displayed or computerized by a component called ADC (Analog to Digital Converter).

Digital numbers are changed in steps. The ADC resolution determines the size of the steps. When the steps are small, the resolution is higher and the accuracy is higher.

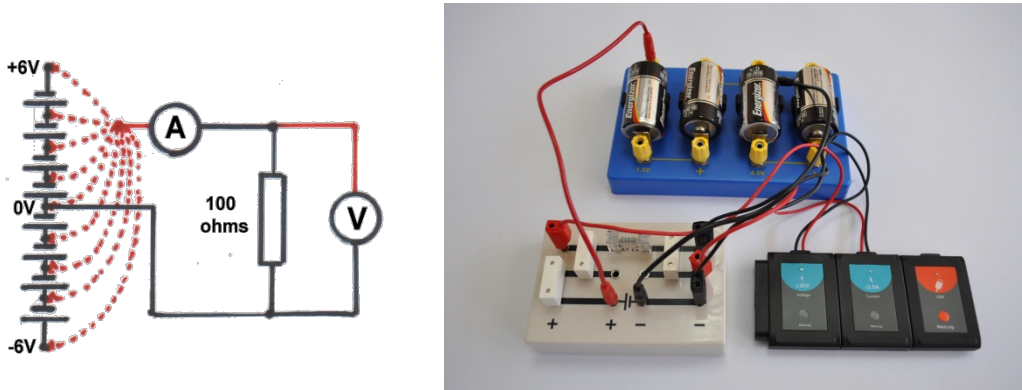
A data-logger is a device that includes an ADC for reading values from several sensors and recording this data in its internal memory. Usually, it has a display for viewing the measured values graphically. The data-logger can be connected to a PC for exporting the recorded data to Excel files or for saving it in files and viewing it on the screen.

The data-logger's capability is characterized by the number of sensors that can be connected to it simultaneously, its memory size, its ADC resolution level and its sampling rate. Its inputs are suited to all available sensors and also to those which will be developed in the future.

The data-logger software analyzes all available sensors.

## 1.2 About logger sensors

The logger sensors system is rather different from almost all other educational data-loggers in that its sensors incorporate their own individually programmable microprocessors and have memory. Hence, each sensor can be viewed as a data-logger in its own right, it records and stores data independently and can be referred to as a logger sensor but within this guide they will just be called sensors.



**Figure 1-1 Voltage-Current Measurement Experiment**

In order to program the sensors, they need to be connected to a Monitor Display Unit (MDU). The MDU can be any kind of PC (Windows, MAC, and Linux), tablet (iPad or Android) or NeuLog viewer. The connection can be by wire using the USB module or wirelessly using the RF module or through the Bluetooth module or the Wi-Fi module. Tablets are connected to the sensors through the Bluetooth module or the Wi-Fi module.

The MDU is the monitor and the display unit only. Data is stored in the sensors themselves. The PC can save the experiments in its hard disk and can load saved experiments at off-line mode.

The sensors can be connected singly or in a chain. The order of connection does not matter and they can be added or removed from the chain without affecting the others.

Depending on their use, sensors can be powered directly from the MDU. However, they can also be powered individually or in chains by a Battery module.

One chain of sensors can be divided into more chains by adding RF communication modules to all the sensors' chains. This allows a remote connection of up to 10 m (in open space).

12 bit resolution is provided for most sensors and sampling rates vary from 10000 per second to 1 per hour, depending on the sensor concerned. The rates available for each sensor match well to their likely use. Experiment durations are from 2 ms to 30 days, depending on the sensor and the sampling rate. A Trigger setting with Pre-trigger is available through which sampling starts and data is displayed from just before the Trigger is operated.

## 1.3 Plug and play system

The philosophy behind logger sensors is a "plug and play" system. Connect the required sensors to the MDU (Monitor Display Unit) and perform the experiment with intuitive software.

There is no need to study data-logger operation. All the measurements, recording and analysis are done by the sensor itself according to its functions. The data sent to the MDU is processed by the sensor.

The total memory of the system is increased since each sensor has its own memory.

Each sensor has its own micro-controller (tiny computer), so it can control and adapt even the hardware to different functions. This is why many of the logger sensors have several ranges or can perform different types of measurements usually done with more than one sensor.

The built-in firmware in the logger sensor can be upgraded at any time using software (without opening the sensor module).

## 1.4 Modes of operation

The Logger Sensors system has two modes of operation: **On-line experiment** and **Off-line experiment**.

**The On-line experiment mode** is where the sensors are connected to the MDU, programmed, and remain connected as the data is fed back continuously in real-time. All sensors gather data at the same rate, are triggered together (a choice has to be made of which sensor to trigger from) and run for the same time.

The On-line experiment mode enables also collection of data at particular stages of the experiment instead of continuously. The **Single-step** mode (sometimes known as 'snapshot') can be used when measurements are taken while some of the experiment variables are changed manually, like changing the source voltage in an electrical circuit, volume in a pressure-volume experiment or adding drops into solutions, etc.

**The Off-line experiment mode** is where the sensors have been programmed by connection to the MDU with different Sampling rates and Experiment durations. The sensors are then disconnected from the MDU and put into battery-powered chains (or singly) to collect their data on the pressing of the sensors' Start/stop buttons. However, in this mode, each sensor can be programmed independently to be triggered to record data as well as having their Start/stop buttons pressed at different times. Up to five experiments can be stored in each sensor.

Reconnection of the sensors to the MDU is required to upload the data and analyze it. However, all graphs would be overlaid on the longest Time axis with  $t = 0$ s being where each sensor appears to have been triggered. Hence it does not take into account the time differences between the pressing of any sensors' Start/stop buttons and their independent triggering.

The sensors can remain connected to the MDU at the **Off-line experiment mode**. As before, the sensors can be programmed with different sampling rates and experiment durations. Again, each sensor can be programmed independently to be triggered to record data. Starting and stopping can be done either by clicking on relevant icons on the MDU or by pressing the Start/Stop buttons on the sensors. Data is then uploaded in order to display and analyze it.

Collected data (in both modes) is stored in the sensors' internal memories, to be displayed as required on the MDU. Each sensor has an ID number that can be changed, when necessary, through software. This would be needed if you were using an array of the same type of sensor, i.e. several temperature sensors, and needed to see what was happening on each one. All sensors are automatically recognized by the system.

## 1.5 Data display and analysis

The computer's display of data can be in the form of a graph or a table, plus a digital display of each sensor's current value e.g. 20°C, 8.95V, 20.9%. The default graph display is of what the sensor measures (Y-axis) plotted against Time (X-axis) but, as mentioned in an earlier paragraph, it is possible to plot XY graphs in which one sensor's data is plotted against another's.

Graphs can have their axis scales pre-selected, can be zoomed to maximize their display in the Y-axis direction, or have small areas selected and zoomed to allow examination in more detail. The graphs of each sensor can be overlaid and their Y-axes moved to convenient positions on the screen.

A best-fit line/curve facility is provided to overlay the graphs, and extrapolation to zero of best-fit straight-line graphs is available. Areas under graphs can be easily calculated for use in determining such a quantity as Impulse from a Force-time graph. Graph plotting can be in 'points only' or in 'a joined up line' and a set of grid-lines can optionally be added.

A number of mathematical functions [ $\log(A)$ ,  $\ln(A)$ ,  $\sqrt{A}$ ,  $A^2$ ,  $1/A^2$ ,  $(A+B)$ ,  $(A \cdot B)$ ,  $(A/B)$ ,  $(1000 \cdot A \cdot B)$ ,  $(A \cdot K)$ , and  $(A/K)$ ] are available with which to convert data, where A and B are the variables and K a constant. The function  $A/B$  would be useful in generating data (and a graph) of the resistance of a filament light bulb, where A is the voltage across the bulb and B the current flowing through it.

These functions allow one to deal with most data processing. The data can also be exported into a spreadsheet for further manipulation and processing.

Triggering is available to start data-logging when a particular sensor's measured value falls or rises below or above a set level. When triggering has been selected, a Pre-trigger display is made available on the graphs and in the tables so that the sensor's values just before the triggering took place can also be seen. This is particularly useful when looking at how the voltage across a coil changes when a magnet falls through it.

Worksheets, incorporating setup details, photographs and diagrams, can be developed and displayed, and saved with or without a Setup Configuration.

### **Note:**

**Additional features will be incorporated in later versions of Logger Sensors and some more sensors will be developed. Revised versions of the software will be provided free to download as they become available.**

## 1.6 About this user guide

This User Guide was designed to go through one complete chapter at a time.

Instructions to do things are indicated by a bullet ■.

Because the measured data is processed in the logger sensor, the software treats each sensor in the same manner except the photo-gate.

The NeuLog™ software is very rich and at the same time intuitive; it is very simple to use.

## 1.7 Safety instructions

- Read and understand these entire instructions before proceeding.
- Keep these instructions.
- This equipment is **not** designed to be used in an environment where failure may result in accident or injury.
- This equipment is designed to operate and perform in an educational environment. It is not designed to be used in a medical, marine or industrial environment.
- Disconnect a module before servicing for any reason. Servicing should be performed by QUALIFIED PERSONNEL ONLY!
- Do not operate a module if it is broken or if its components are revealed for any reason.
- Do not operate a module with a damaged cord, wires or electrical parts. Use only cords supplied with the module.
- Use only a power source approved by the manufacturer.
- The USB module is also an approved power source for NeuLog™ modules.
- Use modules only to measure the parameters for which they were designed as specified on the module label.
- Do not attempt to measure values exceeding those specified on the module label, particularly voltage and current.
- Clean only with a dry cloth.
- Do not install near any heat source such as radiators, heat registers or other apparatus that produce heat.
- Unplug the module during lightning storms or when not used for long periods of time.

## 1.8 Environmental conditions

- Do not expose modules to any kind of liquid.
- Operating temperature: 0°C to +40°C.
- Humidity: up to 95% at 35°C.



### **Power requirements:**

- Battery module (rechargeable batteries) or computer USB outlet.

## 1.9 FCC radio frequency interference statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Connect the equipment into an outlet on a circuit different from the one to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician.

We are not responsible for any radio or communication interference caused by using other than specified or recommended cables and battery or by unauthorized changes or modifications to this equipment. Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

# Chapter 2 – Basic Setup

## 2.1 Installation

**The software and drivers must be installed before connecting any modules to the PC.**

- Download the latest software from [www.neulog.com/software](http://www.neulog.com/software).
- Follow the instructions on the screen. The installation process is straightforward and the required drivers are installed automatically.

The installation is composed of two parts: NeuLog™ software and USB driver. After the installation process is completed, the Logger Sensors software is ready to use.

### Notes:

Upgrading the software can be done at any time. Installing the upgraded software just replaces the relevant files, so uninstalling the software before upgrading is not necessary.

When upgrading the software, the USB driver installation can be skipped by clicking '**Cancel**'.



The NeuLog™ shortcut icon should appear on the PC desktop.


## 2.2 Sensors with tablet or smart phone through Bluetooth

The Bluetooth module can work with tablets or smart phones that support BLE.

- Download the App from the App store or from Google play.
- Turn ON the Bluetooth module (the blue and red LEDs will blink), and run the App.

The App should connect to the Bluetooth module.

- The blue LED on the Bluetooth module will light constantly.

At the top right corner of the App there is a Bluetooth icon . This icon is blue if the App is connected to the Bluetooth module, and grey if it is not.

- Click on the Bluetooth icon to refresh the connection to the module.

## 2.3 Sensors with tablet through Wi-Fi

Most tablets do not have a USB port so we cannot connect a USB module to them.

We can use a Wi-Fi module. This module comes with the NeuLog software which runs on any browser.

This mode of operation has advantages. One can operate the system and run experiments while others view the results and screens.

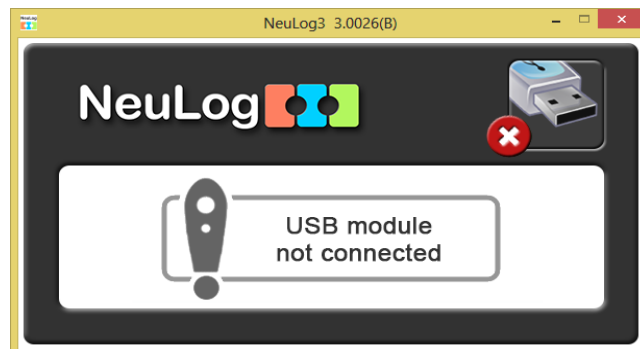
The options of this mode of operation and how to run the software until we get the main screen is described in **appendix B**.

If you are using the Wi-Fi module, use the instructions in Appendix B until you get the NeuLog software main screen and then continue from section 2.4.

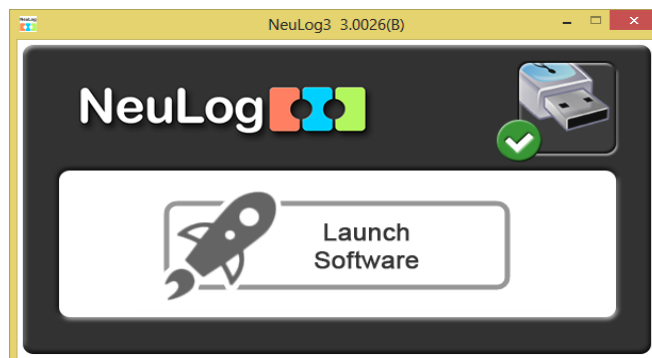
## 2.4 Logger sensors main screen

- Double-click the **NeuLog™ shortcut icon** .

The following screen appears when the USB module is not connected:



The following screen appears when the USB module is connected:



This screen will stay in the background for closing the NeuLog software.

**Note:**

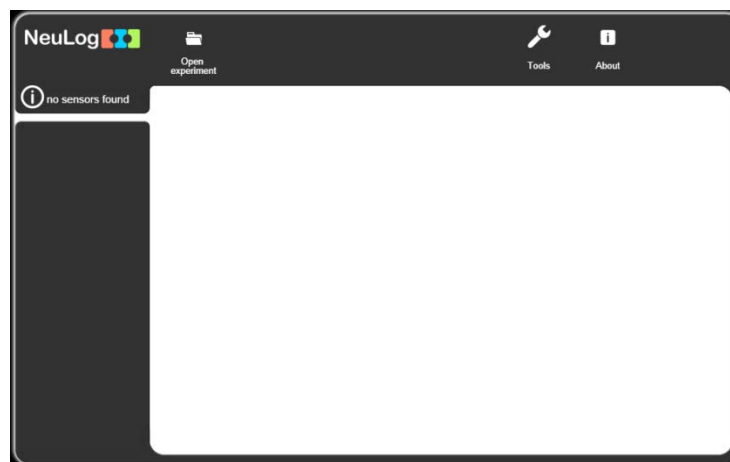
**Closing the NeuLog™ program does not close the app window. The app should be closed separately.**



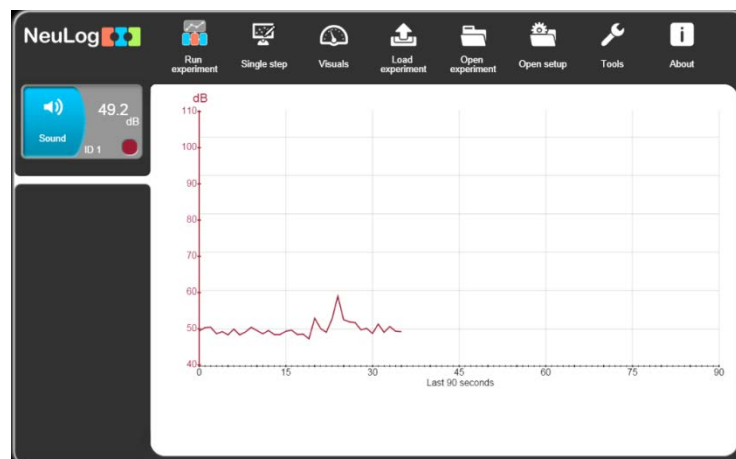
The NeuLog™ application will automatically open in a new app window when the USB module is found. The app starts by displaying the following screen:



The following screen appears if no sensor is connected to the USB module:



The following screen appears if sensors are connected to the USB module:






This screen displays the connected sensors, the current measured value on them and also an accumulated graph of one second rate samples.

The main idea of the NeuLog™ software is that on the screen appear only relevant icons to the current stage of the software.

A search for the connected sensors is done automatically. If the sensors connected to the USB module are changed, the displayed modules on the screen also change in a few seconds.

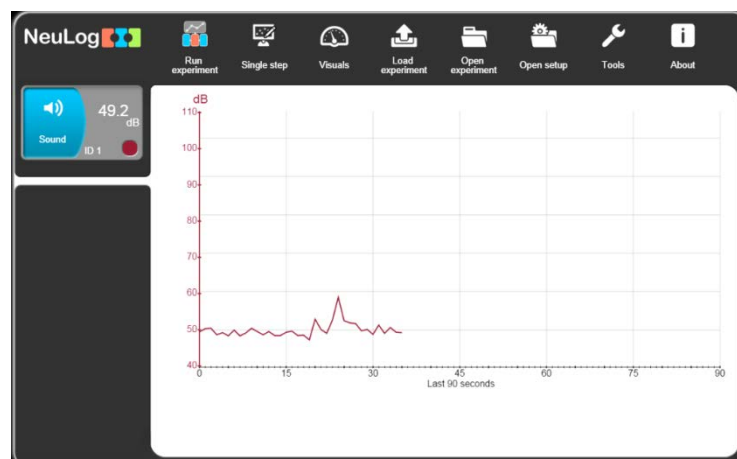
The NeuLog™ software is intuitive and it guides the user on how to use the screen icons. Do not be afraid to play with the system. This is the main idea of NeuLog™ – use it and have fun.

## 2.5 Connecting a sensor

- Connect the **USB module**  to a USB port on the PC with the USB-mini USB cable.
- Connect the **Sound sensor**  to the **USB module** .


Each module has two connecting sockets – a female socket at one side and a male socket on the other side. The sockets enable you to connect the sensor modules in a chain.

- The program will scan and display the connected sensor's module box, in this case that of the sound sensor, automatically in the module window on the left-hand side of the screen as shown below:



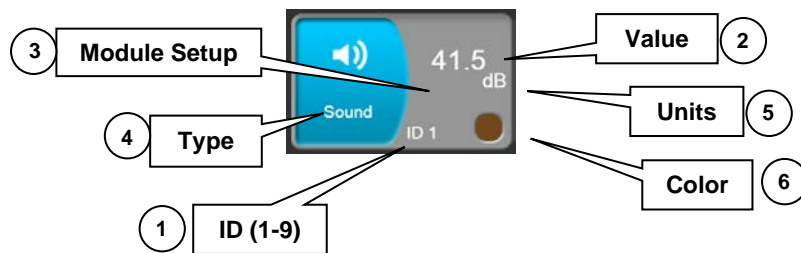
A search for the connected sensors is done automatically. Changing the sensors connected to the USB module changes the displayed modules on the screen in a few seconds.

Any newly detected sensor module boxes are displayed vertically in the module window.

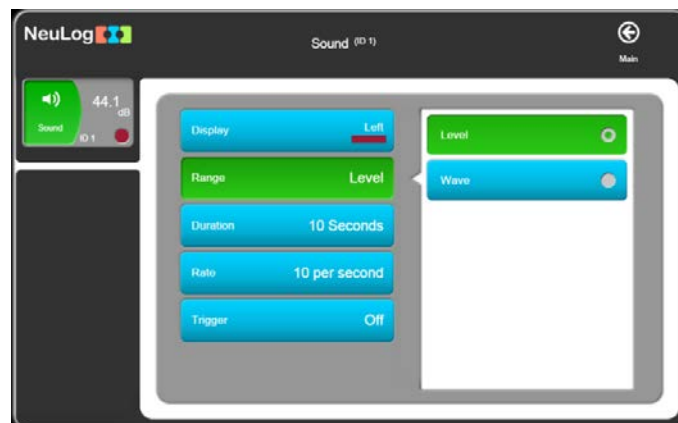
The software strives to achieve maximum intuition; only the relevant buttons for each stage are shown. The  button brings you back to the previous step.

This is the "plug and play" method. Connect the sensors to the PC through the USB module, run the software and the system is ready to use.

## 2.6 Sensor module box



1. **ID** – Displays the sensor's ID. Up to 9 sensors of the same type can be connected in a chain.
  2. **Value** – Displays the sensor's numerical value.
  3. **Module Setup** – Opens the sensor's setup window.
  4. **Type** – Displays the sensor's type (Light, Temperature, etc.).
  5. **Units** – Displays appropriate units of measurement (lx for a light sensor, °F or °C for a temperature sensor, etc.).
  6. **Color** – Displays the color of the sensor's graph. It can easily be changed. The numbers and units of the Y axis will be also displayed in this color.
- Pressing on the sensor module box opens the parameter window (Module Setup) for that particular sensor.



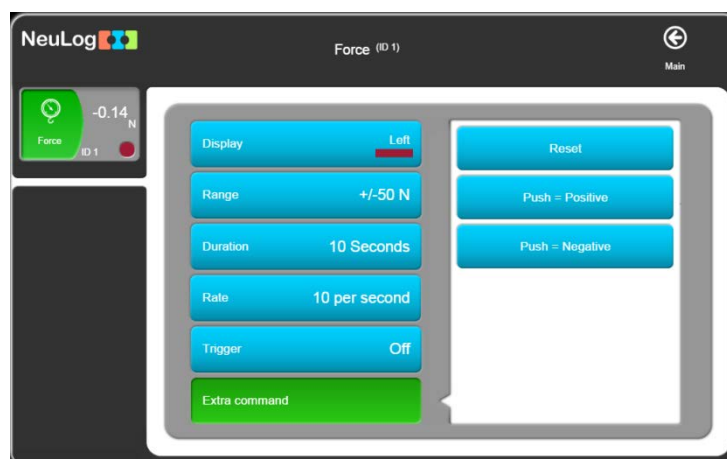
- The measurement range of the sensor is set through the Range button; the default button appears selected.

- In order to determine whether a sensor will participate in the experiment or not, what will be the color of its graph, where will be its Y axis and what will be the axis limits, press the Display button.




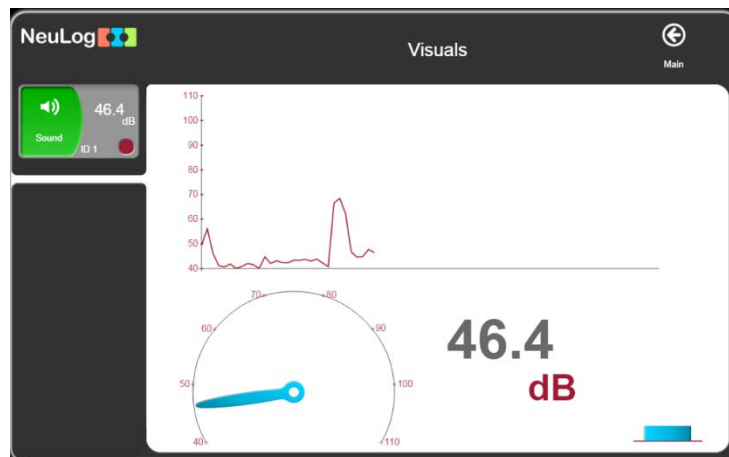
The **Duration**, **Rate** and **Trigger** buttons are aimed for experiments where every sensor has its own experiment setup parameters.

- Some sensors have extra commands (such as reset, calibrate, etc.). These sensors have an **Extra Command** button as in the following Force sensor screen:




## 2.7 Visuals mode

- Pressing the **Visuals Mode**  button will display the Visuals screen, which shows the measurements in four display modes:
  - a. Bar graph
  - b. Digital display
  - c. Analog display
  - d. Accumulative graph with a new sample every second. The graph shows the last minute.







- To change the sensor for which results are displayed, press on the sensor's module box.
- To enter the change parameters screen for a specific sensor, press on the sensor's module box associated with that sensor.

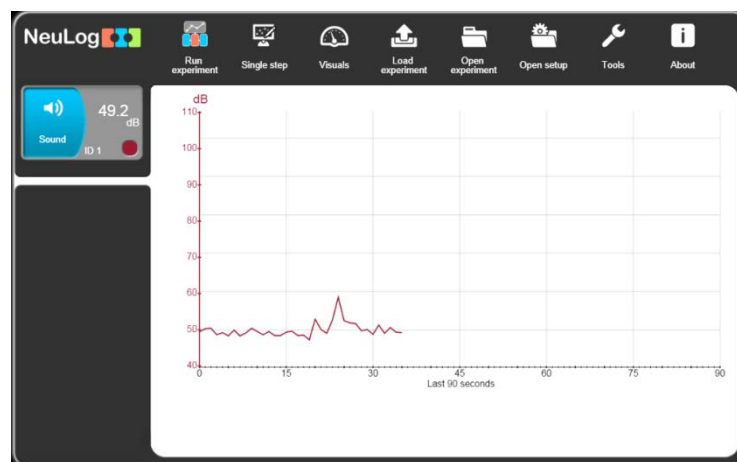


- Press the  button to return to the main screen.


# Chapter 3 – On-line Experiment Mode

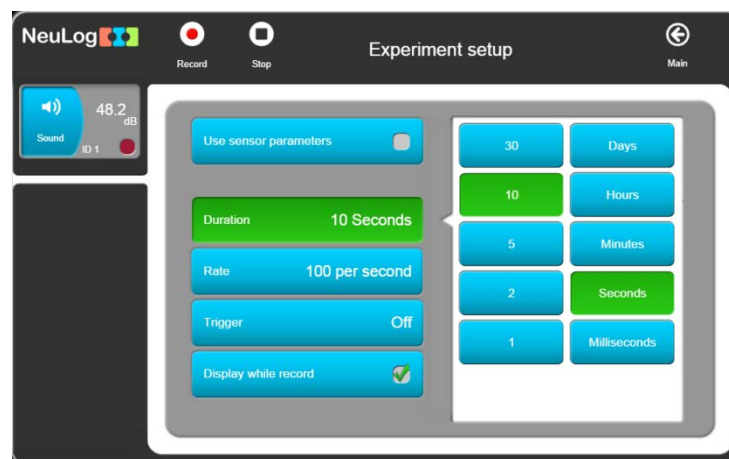
This chapter describes an experiment with the sound sensor where the features of the **On-Line Experiment** mode are used. The experiment is controlled by the PC and the results are recorded and displayed in real-time.

- Connect the **USB module**  to a USB port on the PC.
- Connect the **Sound sensor**  to the **USB module** .
- Double-click the **NeuLog™ shortcut icon**  to display the following:



## 3.1 Experiment setup

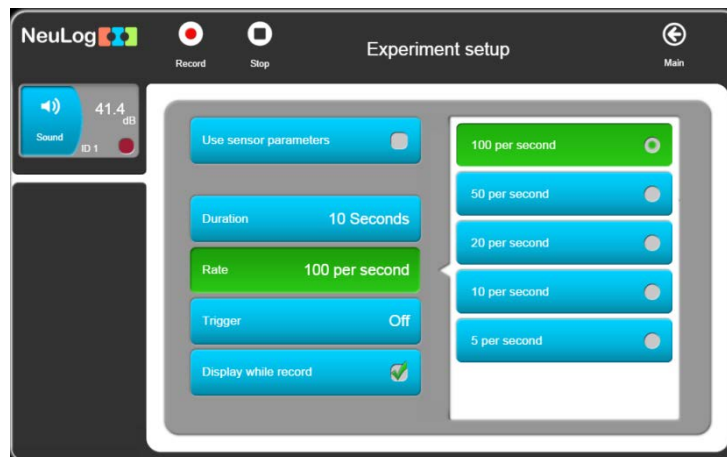
- Click on the **Run experiment**  button to display the Experiment setup screen below.



- In this window the experiment parameters are defined: **experiment duration**, **sample rate** and **trigger** for all sensors.

Two buttons are used to define the experiment duration: number and time units.

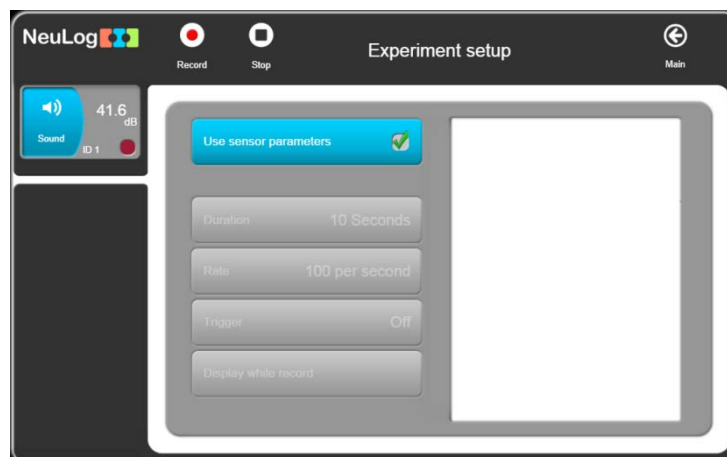
- Use the **Rate** button to change the sample rate.



The **Trigger** function will be discussed later.

The default is to show a graph while the measurement is performed. The **Display while record** button appears as selected. If it is unselected, you will not see a graph on the screen while the measurement is performed.

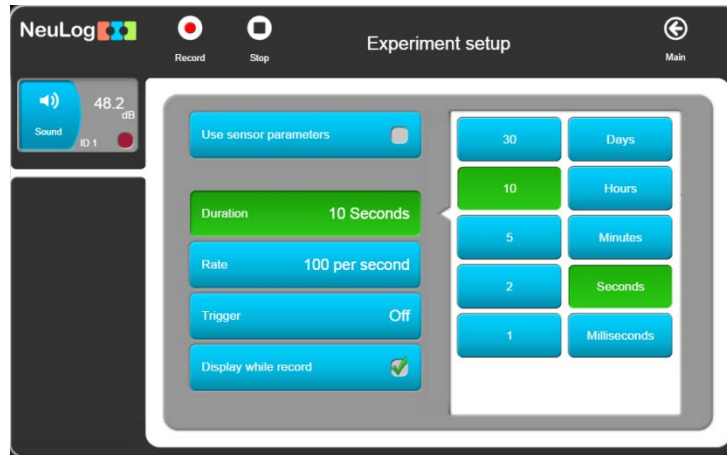
Selecting the **Use sensor parameters** button will change the screen to the following:





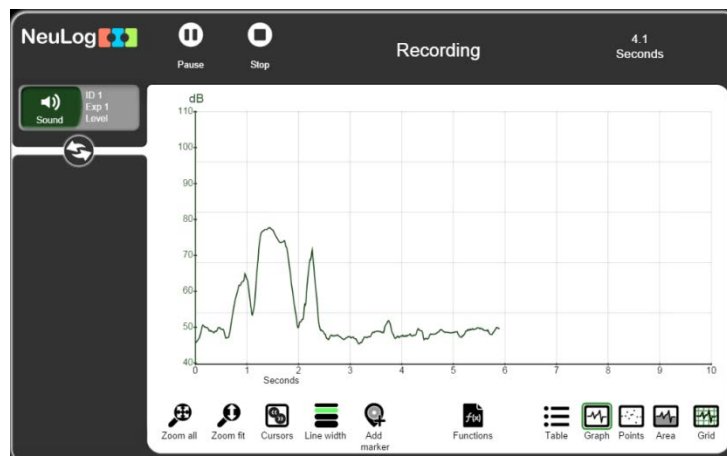
The experiment will run with the sensor setup parameters as described in section 2.5.

## 3.2 Recording an experiment

- Unselect the **Use sensor parameters** and define the Duration to 10 seconds and the Rate of to 100 samples per second as in the following screen:

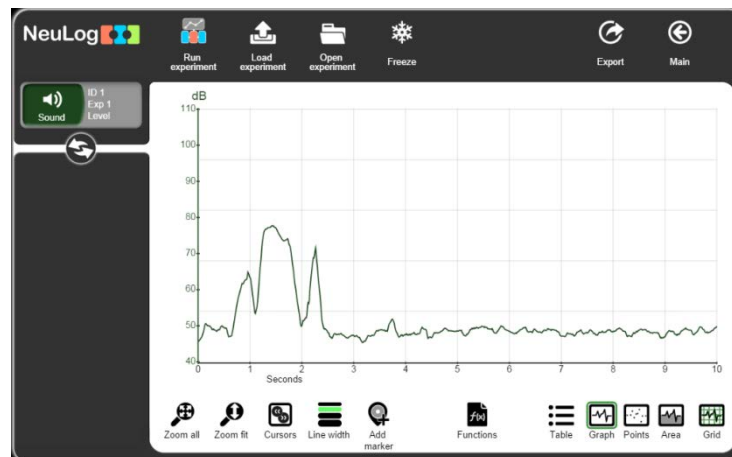


- Press on the **Record**  button to run a measurement; a graph is built online. The measurement can be stopped before the end by pressing the **Stop**  button.




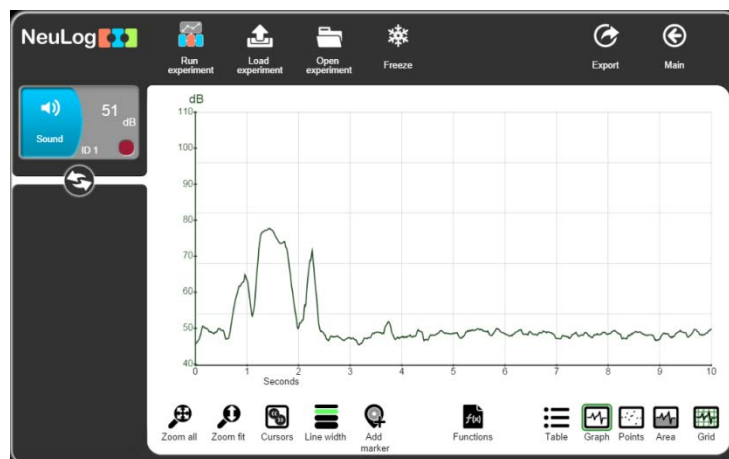



When the experiment ends, the following screen appears:




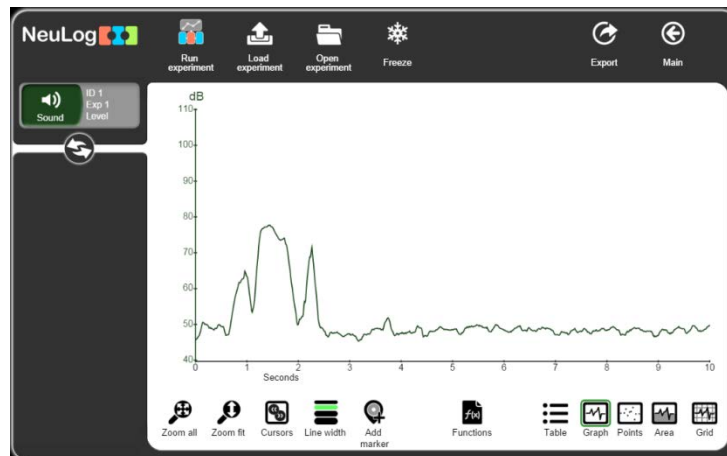
The sensor's module box on the left gives information about the experiment graphs shown on the window. No measuring values appear.



- To recover the sensor's module box with live sensor buttons, click on the  button at the bottom of the module box.

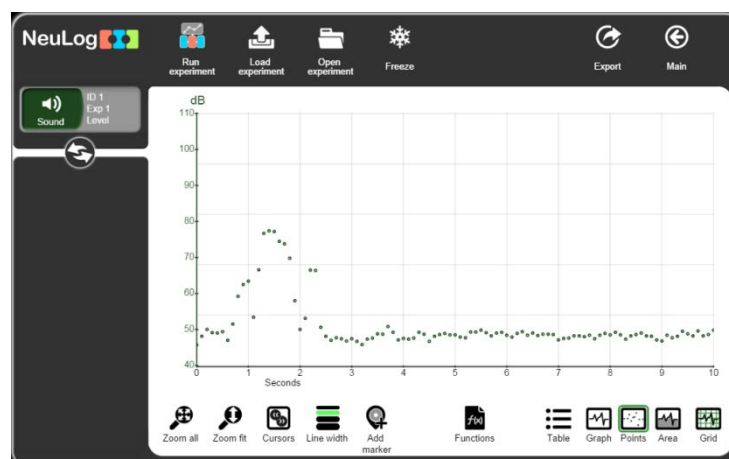



- Click on the  button again to replace the live sensor buttons with graph sensor buttons.

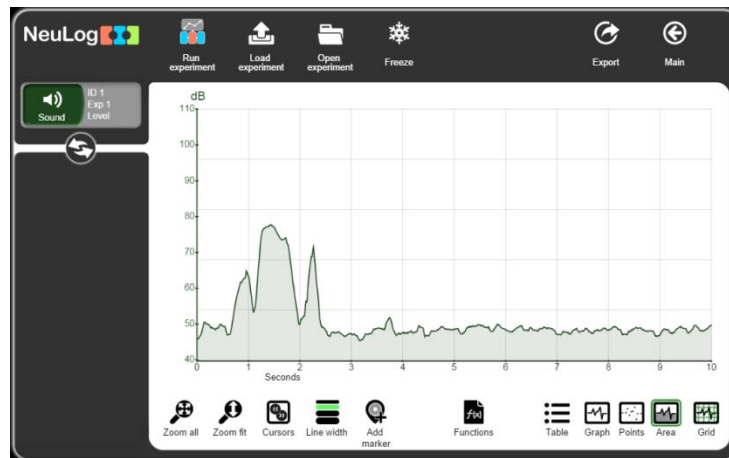
- Click on the **Grid**  button to hide the vertical and horizontal lines of the graph.




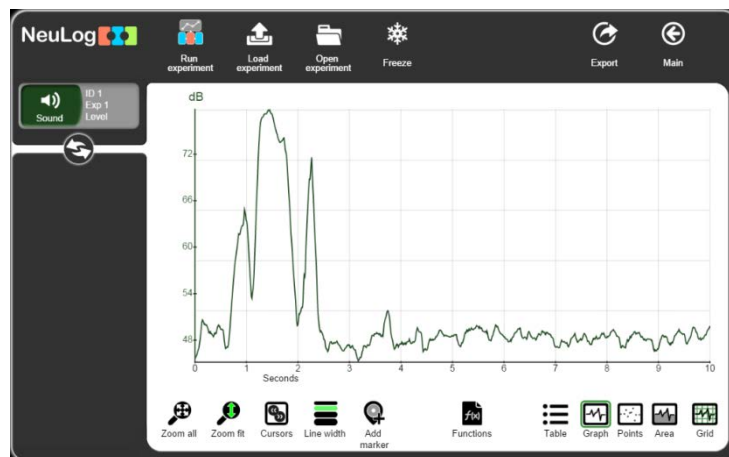
- Click on the **Grid** button to show again the vertical and horizontal lines of graph.
- To convert a graph to a series of points, click on the **Points**  button. To return to the regular graph mode, click on the **Graph**  button.




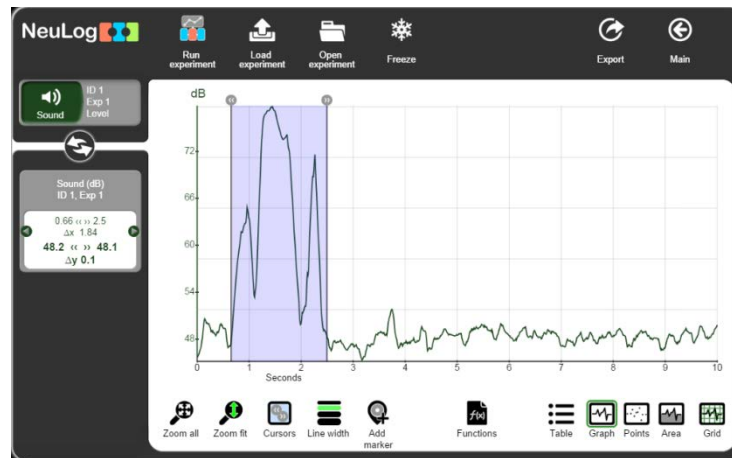
- To show the area below the graph, click on the **Area**  button. Press on the **Graph** button to cancel.




- The **Zoom Fit**  button adapts the graph Y axis and expands it accordingly. It turns green when activated.

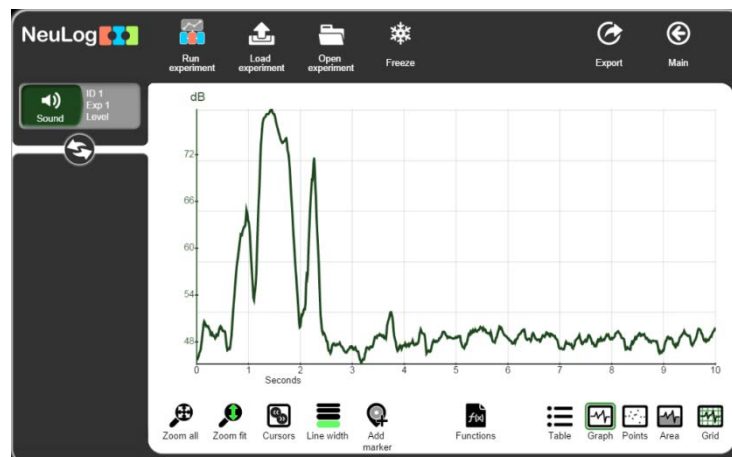



- Click on the **Cursors**  button to choose a segment of the graph. The result of the expanded graph segment is shown below.

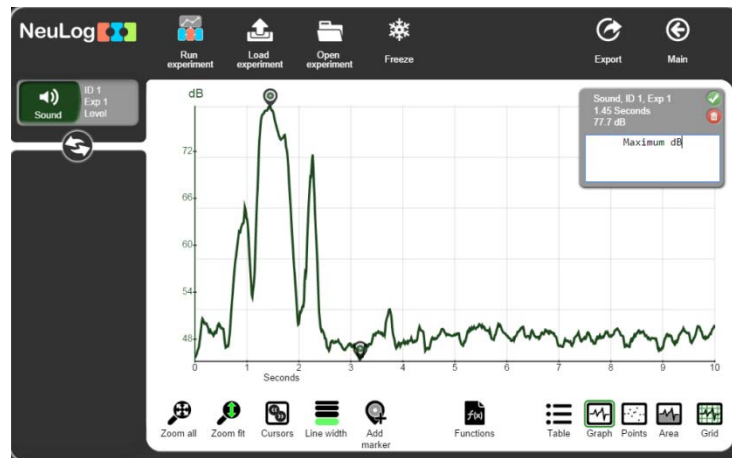



Each cursor can be dragged to the right or to the left. The parameters on the left column change accordingly.

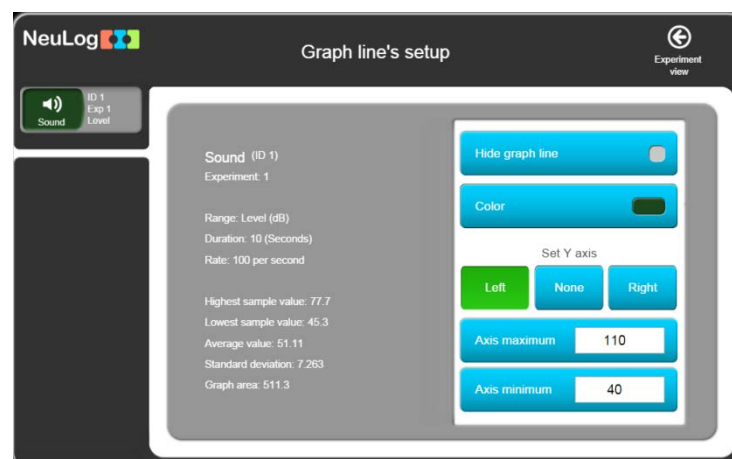
- Click on the **Line width**  button to change the width of the graph line.




- Click on the **Add marker**  button to add a marker to a certain point on the graph. You can then add a comment or description of this point. Click on the ✓ to save the comment.

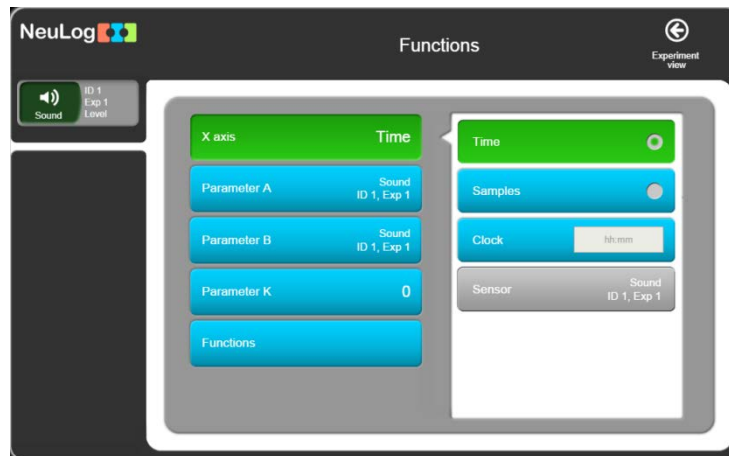


- Click on the **Garbage**  button in the comment box to delete the marker.
- Click on the sensor's module box on the left to obtain the following screen:

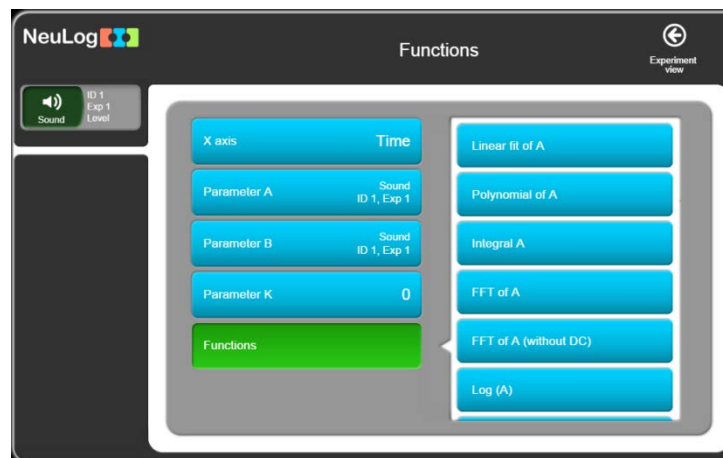


This screen shows statistical analysis of the graph and the display options of it.

- The **Functions**  button allows us to manipulate mathematical functions on the graph.



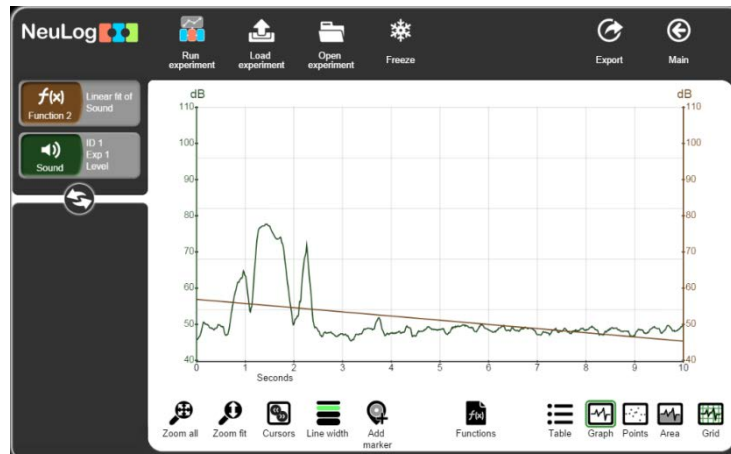
- The options of the X axis button are: **Time** (default), **samples**, **clock** and **sensor** (XY graph when more than one sensor participates in the experiment).
- The manipulating function can be operated on one sensor (defined as parameter A), on two sensors (the second is defined as parameter B), on a constant value (defined as parameter K) on a sensor (parameter A).
- Click on the **Functions** button in the above screen to open the following list of functions:



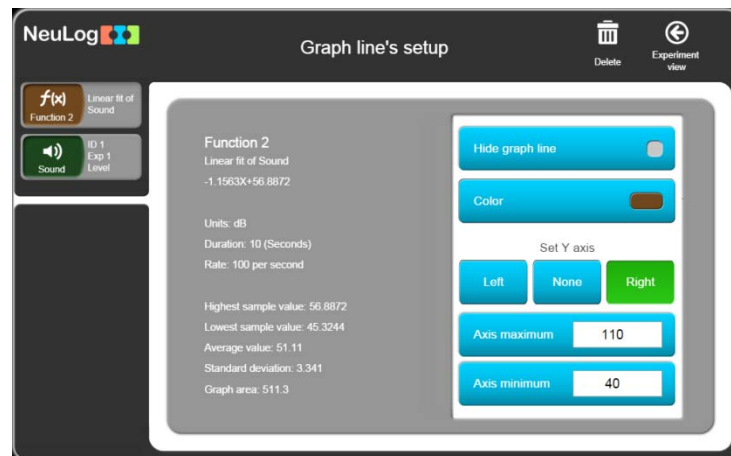
The optional functions are:


▪ <b>Integral A</b>	▪ <b><math>e^A</math></b>
▪ <b>Linear fit of A</b>	▪ <b><math>10^A</math></b>
▪ <b>Polynomial K of A</b>	▪ <b><math>A + K</math></b>
▪ <b>FFT of A</b>	▪ <b><math>A * K</math></b>
▪ <b>FFT of A (without DC)</b>	▪ <b><math>A / K</math></b>
▪ <b>Log (A)</b>	▪ <b><math>A + B</math></b>
▪ <b>Ln (A)</b>	▪ <b><math>A - B</math></b>
▪ <b>Square root of A</b>	▪ <b><math>A * B</math></b>
▪ <b><math>A^2</math></b>	▪ <b><math>A / B</math></b>
▪ <b><math>1 / A</math></b>	▪ <b><math>dA / dB</math></b>
▪ <b><math>1 / (A^2)</math></b>	▪ <b><math>dA / dB^2</math></b>

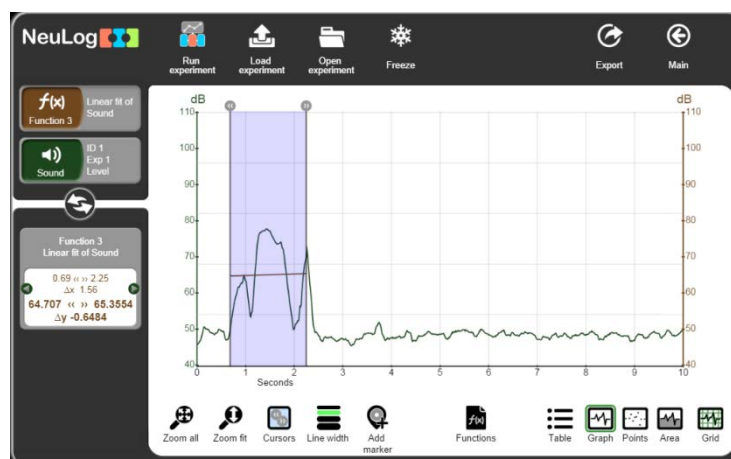
- Every function creates a new graph with a new graph box that can be function manipulated too, as in the following screen of Linear Fit:




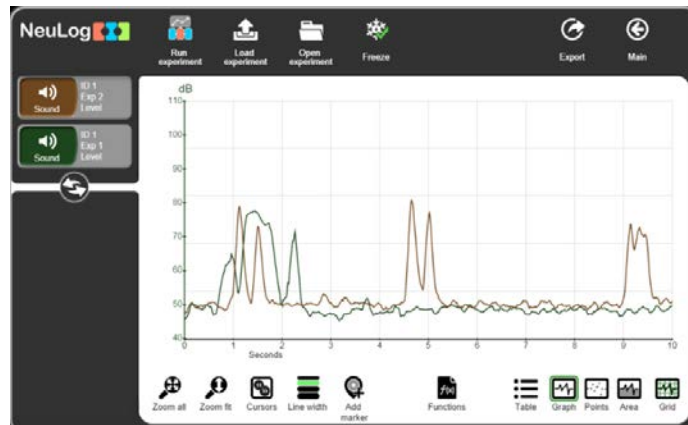
- The formula of the linear fit graph can be found in the data screen of the function 2 graph symbol:



- The graph can be deleted by clicking on the **Delete**  button on the right on top.
- When a range is defined by cursors, the function is manipulated on the defined range only, as seen below:

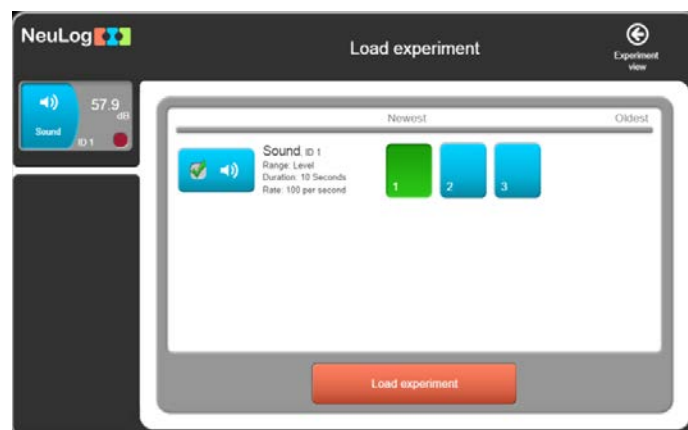


- Clicking on **Freeze**  button and running a new experiment, will show the two experiment graphs:

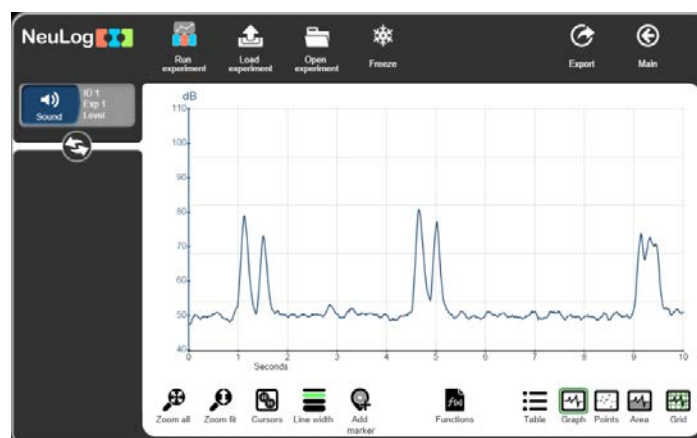


- Every sensor saves the measurement in its flash memory, while sampling. The sensor can save up to 5 measurements.

Clicking on the **Load experiment**  button opens the following screen for loading measurements from the sensor's flash memory:



- Select the required experiment and click on the orange **Load experiment** button to load the experiment's data from the sensor.



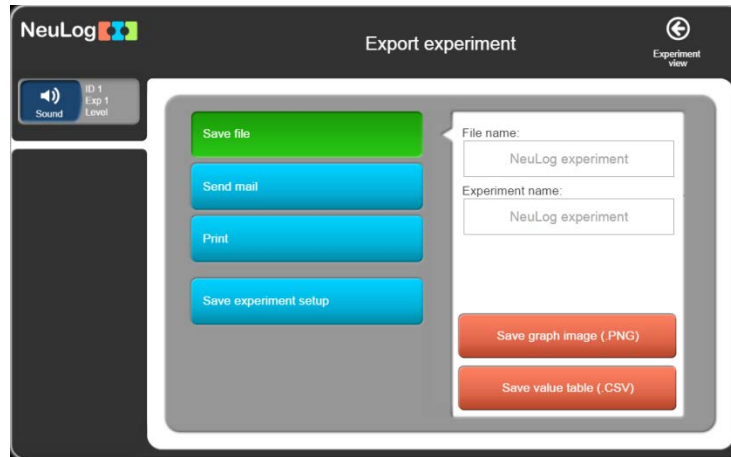
**Note:**

If the experiment's duration or sampling rate is changed, the RAM memory of the sensor is erased.



### 3.3 Save and open

- To store the results of an experiment in a file, click the **Export**  button.

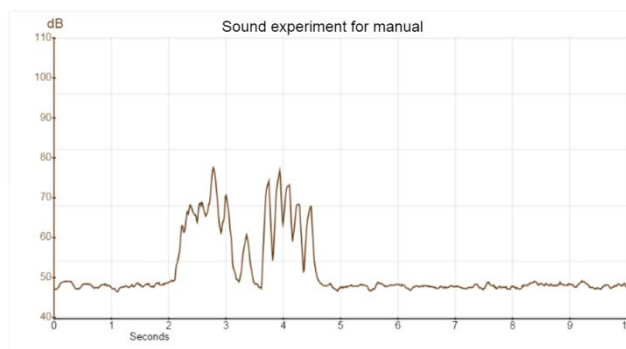


- NeuLog's saving format is CSV so that it can be opened also by spreadsheet programs (like Excel).

Enter the file name and the experiment name and click on the **Save value table (.CSV)** button.

- A dialog box opens.  
Browse to the required directory and click **Save**.
- This is a CSV file; it will also appear on the bottom left of the screen.  
Click on it to open it under a spreadsheet program.
- The experiment can also be saved as a picture (.PNG) of the graph. To do so, click on the save graph's image (.PNG) button.
- A dialog box opens.  
Browse to the required directory and click **Save**.
- This is a .PNG file; it will also appear on the bottom left of the screen.

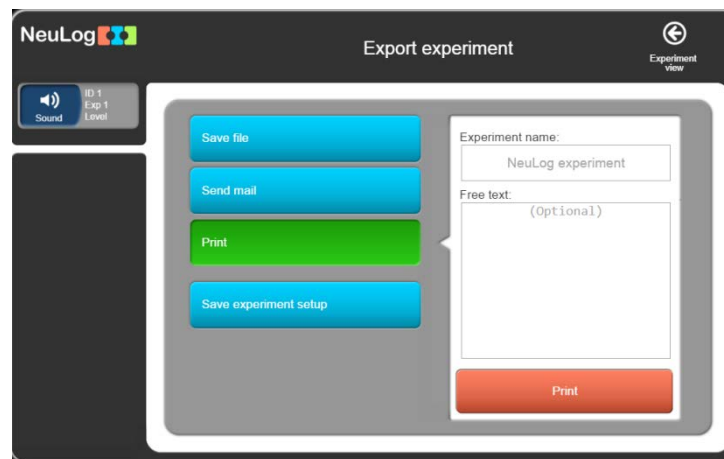
Click on it to see the picture of the graph on the screen.



- The experiment can be sent by email by clicking on the **Send email** button.

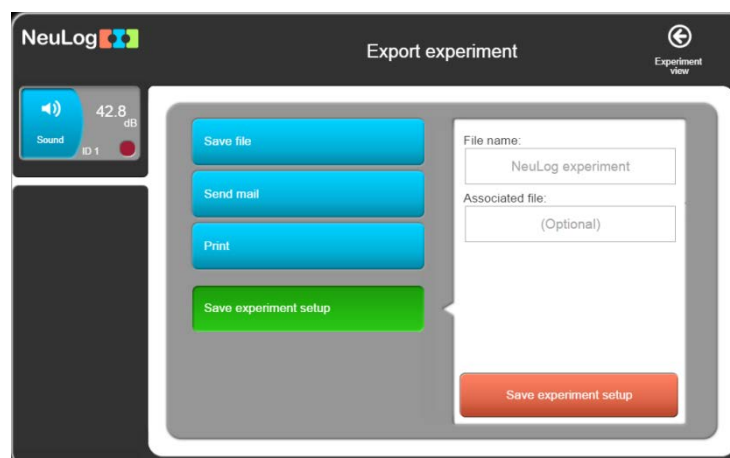


- The graph can be printed by clicking on the **Print** button.




- The experiment parameters (such as sensors' ranges, duration, rate, trigger values) can be saved as a file by clicking on the **Save experiment setup** button.

This is useful when we want to shorten the setup time of an experiment. When we load a setup file, the experiment parameters are set automatically.

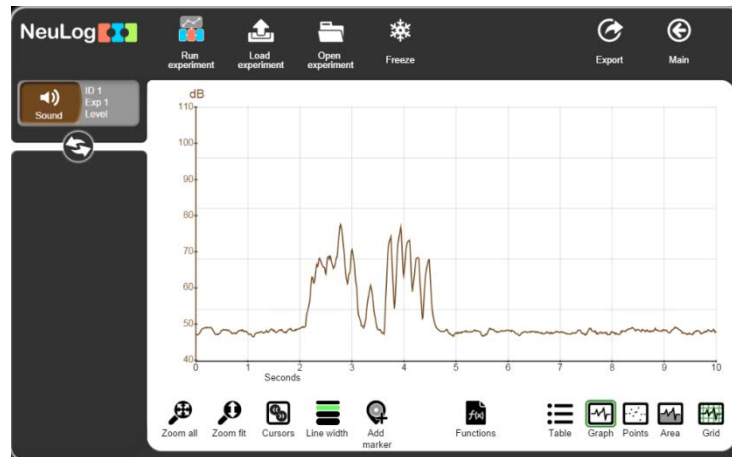


- Click the  button to go back.

- To open an experiment, click on the **Open Experiment**  button.

An explorer dialog box opens.

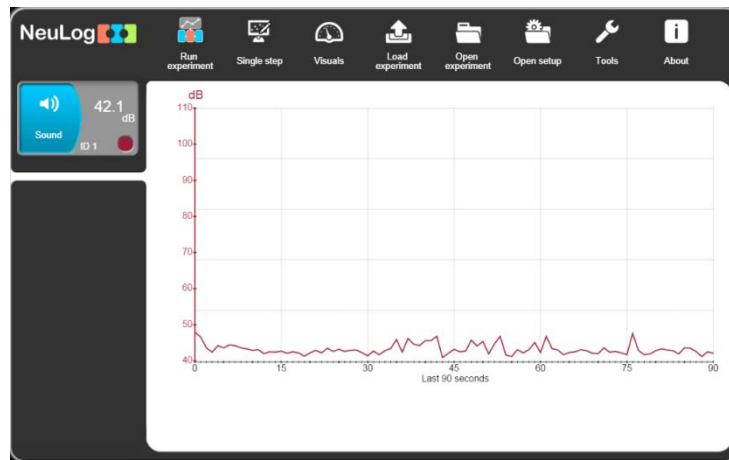
Browse to the download files library and select the saved file.



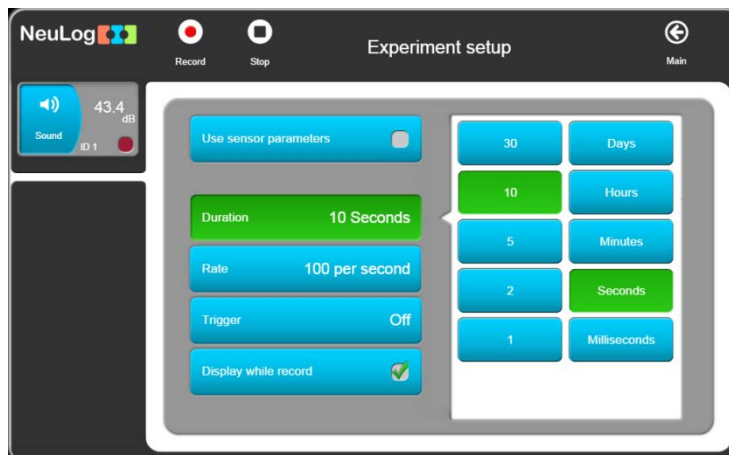
You can freeze the graph and another experiment can be opened or loaded from the sensor's memory to compare experiments.

### 3.4 Experiment with trigger

- Return to the main screen.



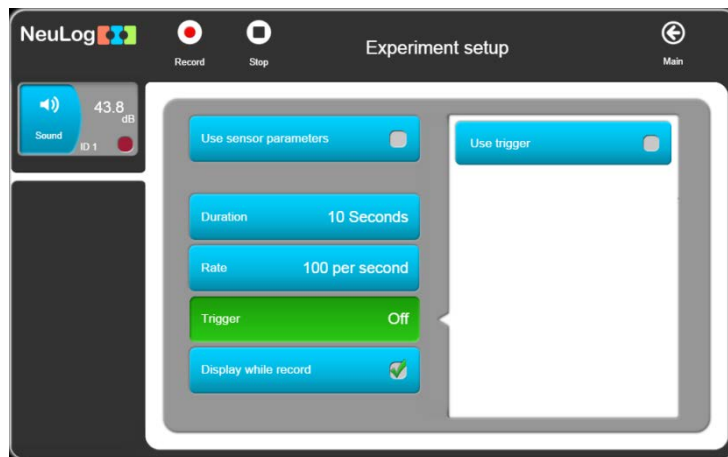
- Click on **Run experiment**  button.



- Experiments which are defined to start with a trigger, will start only after the value of a specific sensor exceeds a predefined measured signal level.

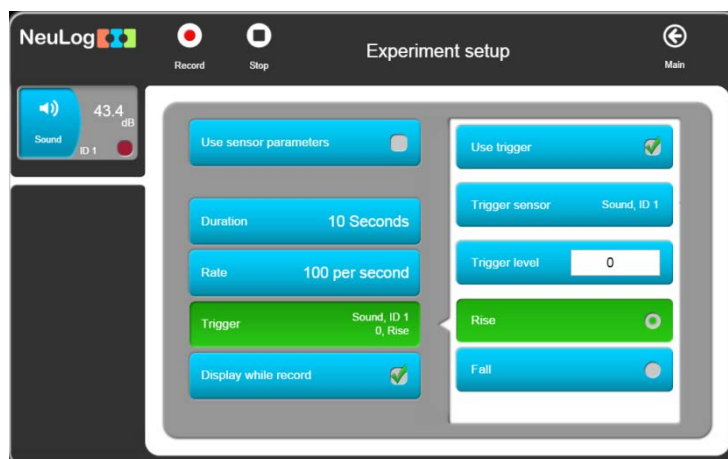
The trigger can operate on either a rising or falling sensor signal.

Click on the **Trigger** button.

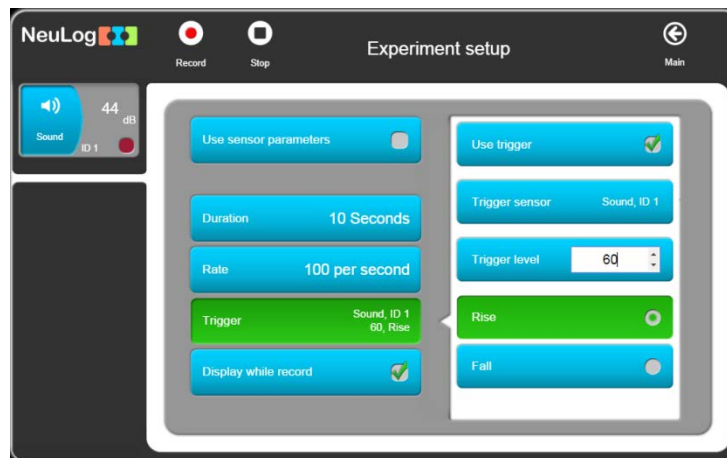



- Select the **Use trigger** option.

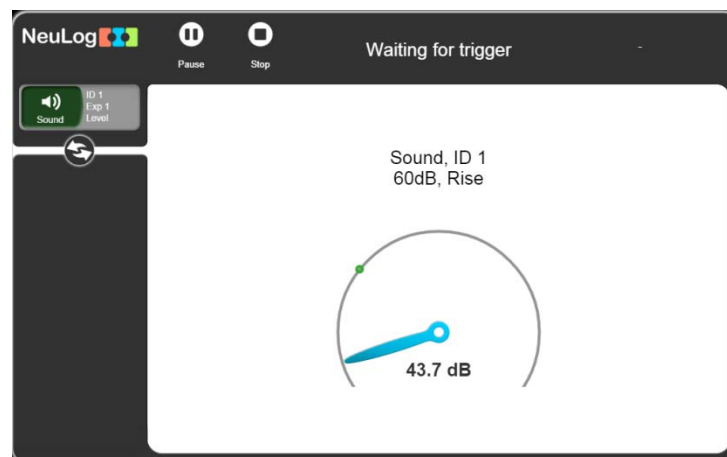
The screen for defining parameters for an experiment with a trigger is shown below.



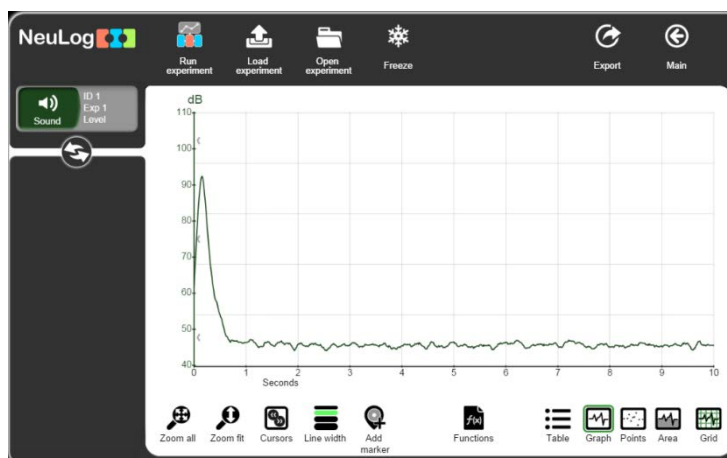
- Enter 60 as **Trigger level** and select **Rise**.
- The following shows the experiment setup menu after the experiment parameters, including the trigger, have been defined.



- After clicking the **Record**  button, the following screen appears displaying the **Waiting for Trigger** message to start sampling.



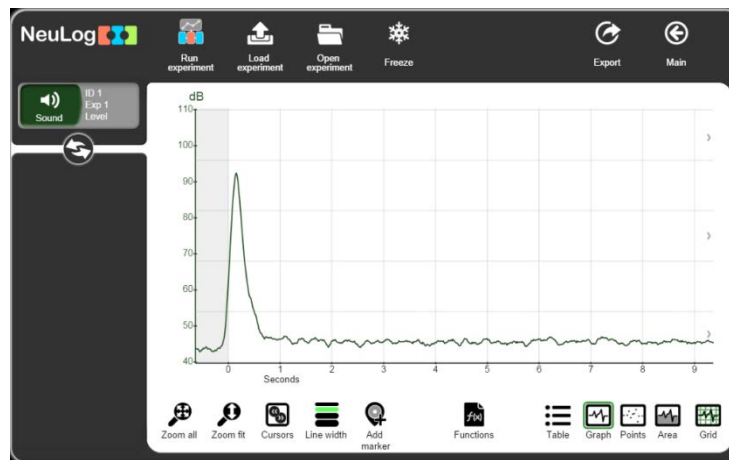
- Make a noise above 60 dB and observe the graph on the screen.




- Pay attention to the level at which the graph starts.

- The system saves samples also before the trigger is received.


Click with the left mouse button anywhere on the graph window, keep the mouse's button pressed and pull it to the right.



The grey area shows the values before the trigger.

- Click on the **Table**  button to display the samples from an experiment before and after the trigger in a table.

Time: Seconds	Sound (dB) ID 1, Exp 1
-0.06	49.1
-0.05	50.7
-0.04	52.9
-0.03	55.3
-0.02	57.4
-0.01	59.6
0	62.0
0.01	64.4
0.02	67.0
0.03	70.0
0.04	72.9
0.05	75.9

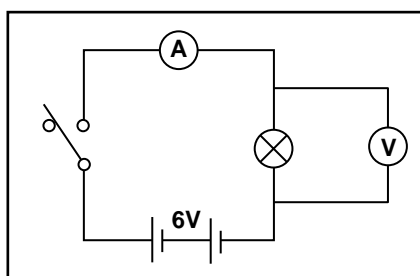
To return to the graphic display, click on the **Graph**  button.

### 3.5 Experiment with more than one sensor

There are experiments in which two sensors are used. Their data is plotted, not against Time, but against each other. Examples of this are graphs of (i) the Voltage across a component (e.g. resistor, light emitting diode or bulb) against the current flowing through it and (ii) the Pressure of a fixed mass of gas (at constant volume) against the Temperature of that gas.

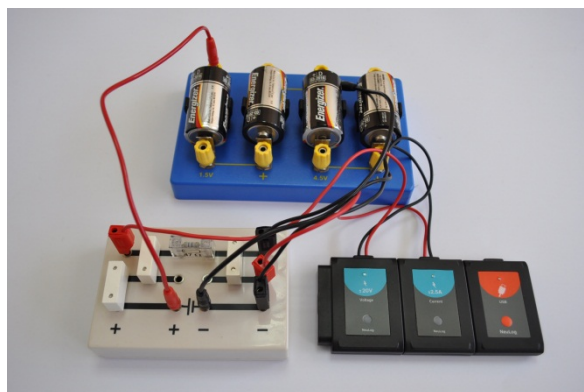
In the following experiment, you can see at the first of these two examples as a small filament light bulb is switched on.


Connect the circuit shown below.



**Circuit diagram**

This circuit is ideally mounted on an electricity experiment box (the white box in the photo) so that there are sockets available for the sensors to be plugged into. The ideal switch is a micro switch with lever and the bulb a MES tubular 6.5V 300mA. A 6V battery should be used (plugged into the cell holder – the blue box in the photo). It should look as follows:



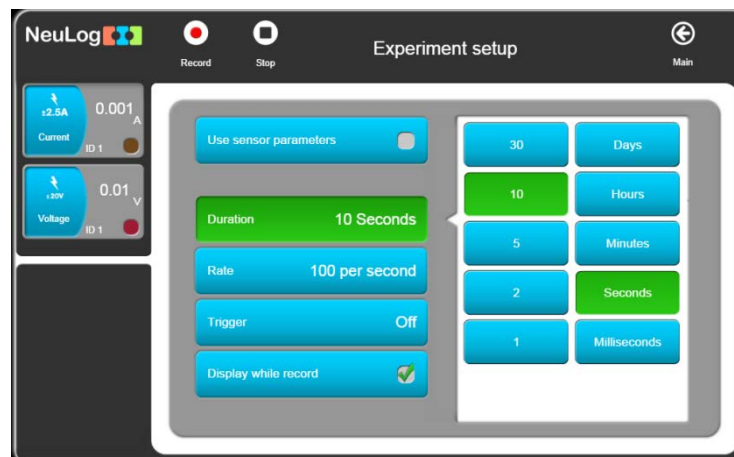
- Connect a **Voltage sensor**  to the **USB module** .
- Connect a **Current sensor**  to either the **USB module**  or to the **Voltage sensor** .
- Plug the Voltage sensor's red and black 4mm plugs into the sockets across the bulb, red plug to red socket and black plug to black socket.
- Plug the Current sensor's red and black 4mm plugs into the other two sockets, red plug to red socket and black plug to black socket.



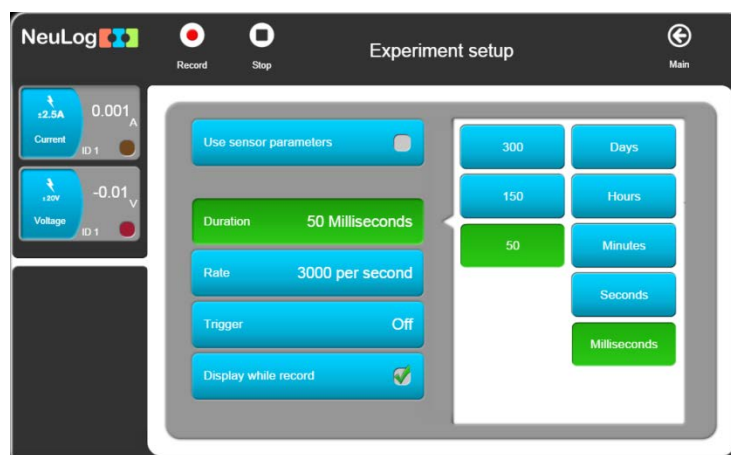
- Open **NeuLog**'s main screen; the Voltage and Current sensor module boxes are displayed as shown below.



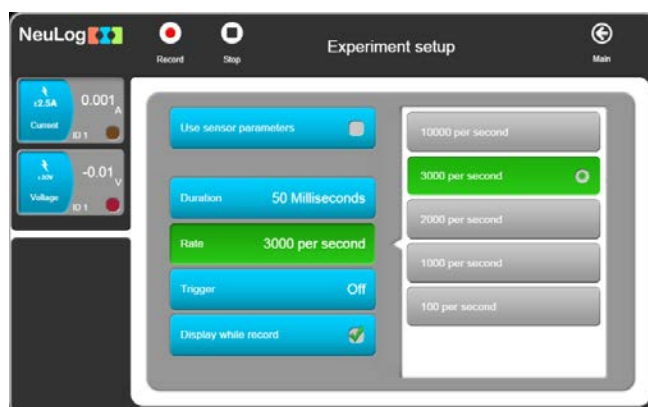
- Click on the **Run experiment**  button to open the experiment setup screen.



- Switching on the bulb is a very fast event, so click on the **Milliseconds** button and choose 50 for **Experiment duration**.



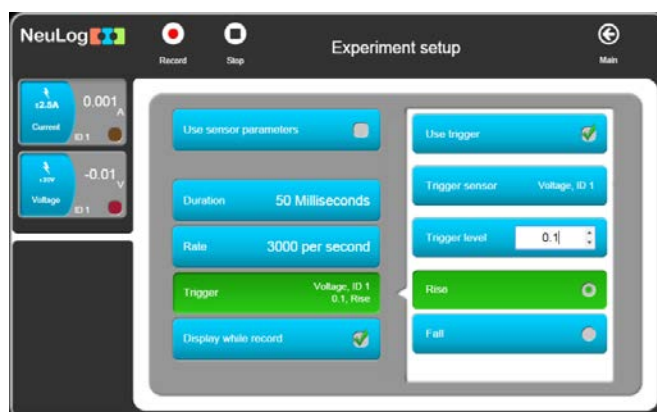
- Select '3000 per second' for **Sampling rate**.



With such a fast event, you need to use the **Trigger** to begin the data logging.

To trigger the sampling, use the rise in voltage across the bulb as the switch is closed.

- Set the trigger parameters to **Voltage 1** sensor, **Rise** and **0.1** as shown below.

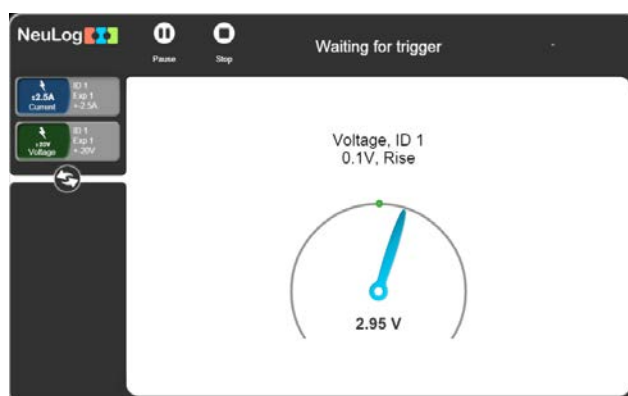


Alternatively, you can set the Trigger based on the Current sensor, Current 1, rising to a level of 5mA, for example.

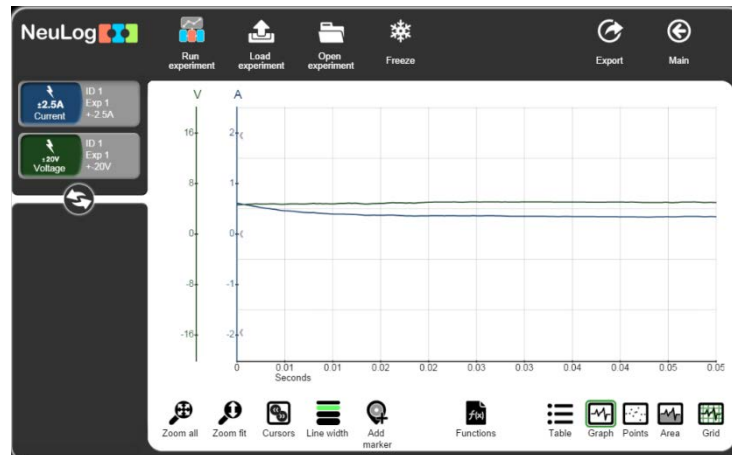
At this stage, it is useful to first see each graph plotted against Time.

- Click on the **Record**  button.

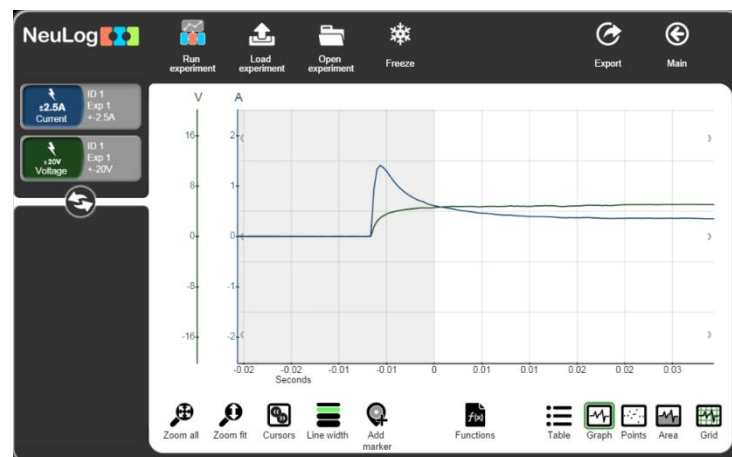
The message 'Waiting for Trigger' is displayed on the screen.



- Now close the switch and hold it closed for a second or so; graphs similar to those below should be plotted.

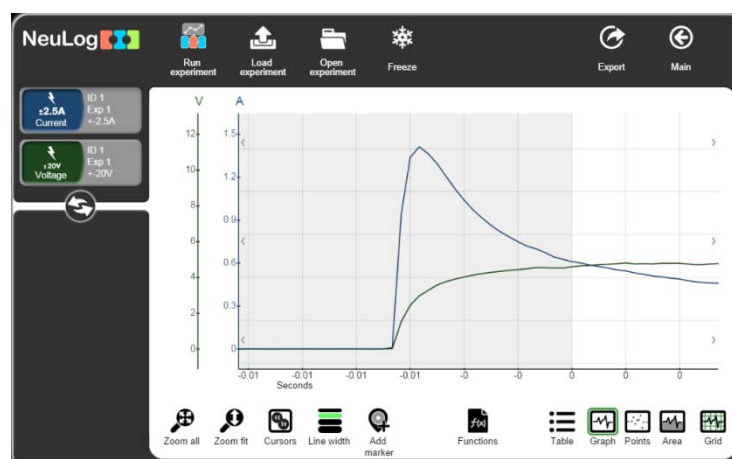


- Drag the graph to the right to observe the pre-triggering area; what was happening to the current through the bulb and the voltage across it, just before and at the moment the switch was closed is displayed.




The interesting section of the above graphs is obviously just before the bulb was switched **ON** until the bulb was fully lit, where the two graph-lines level off. This section will be explained in more detail in the following page.

- Use the mouse wheel to zoom in and to increase the size of the graph.

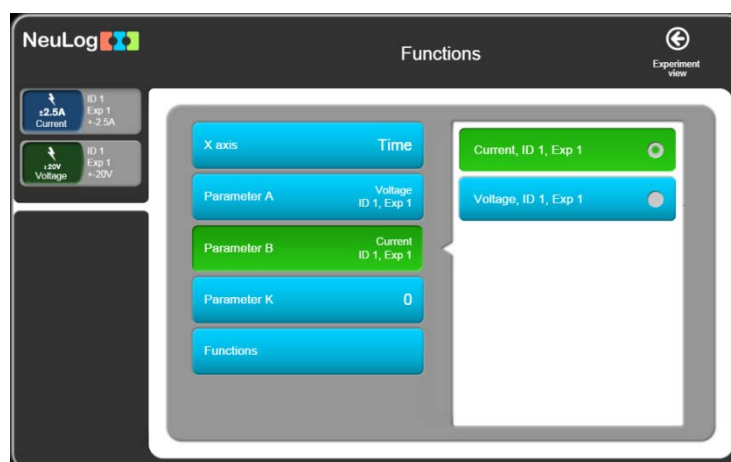


### 3.5.1 Using the functions button

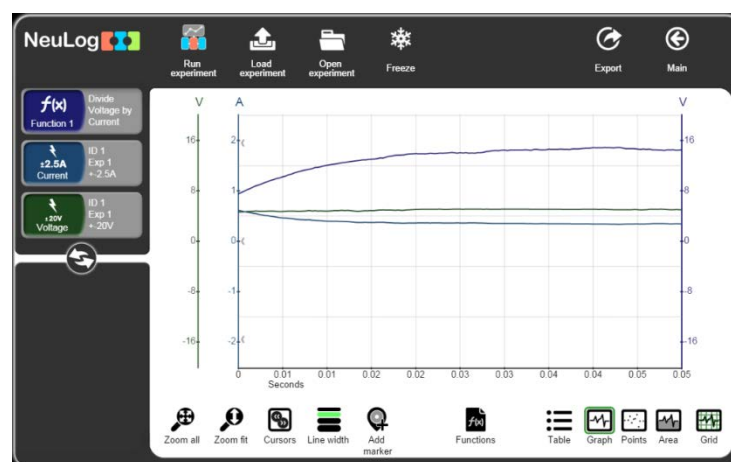
With both voltage and current data available, you can now obtain a graph of how the resistance of the bulb changed with time by generating a graph of (voltage across the bulb divided by the current flowing through the bulb) plotted against Time. The function window provides a number of mathematical functions with which to generate new data from what we have (in this case, to calculate the resistance of the bulb).

If there is more than one sensor, it is possible to analyze the measured results with mathematical functions for two sensors clicking on the **Functions**  button.

- Select the voltage sensor as **parameter A** and the current sensor as **parameter B**.

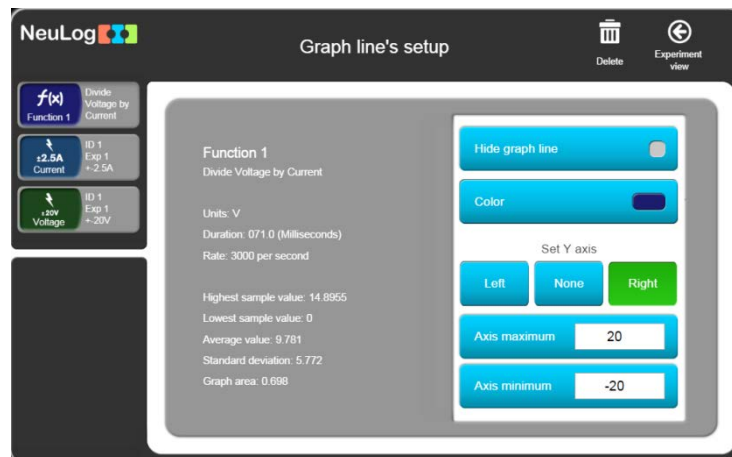


- Click on the **A / B** button to see displayed the original graphs of Voltage against Time and Current against Time, and an additional graph (in blue) of Voltage/Current against Time as shown below.



We can see how the resistance of the bulb goes up when the bulb turns on.

- Click on the  $f(x)$  button (on the left side of the screen) for the following screen:

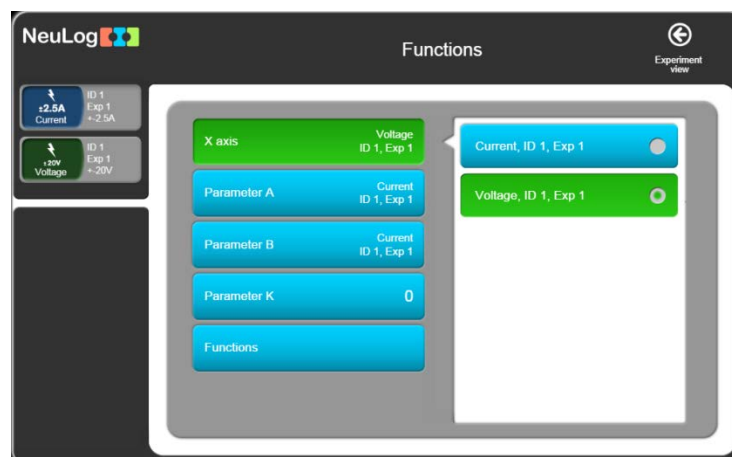



- Click on the **Delete**  button to delete this graph.

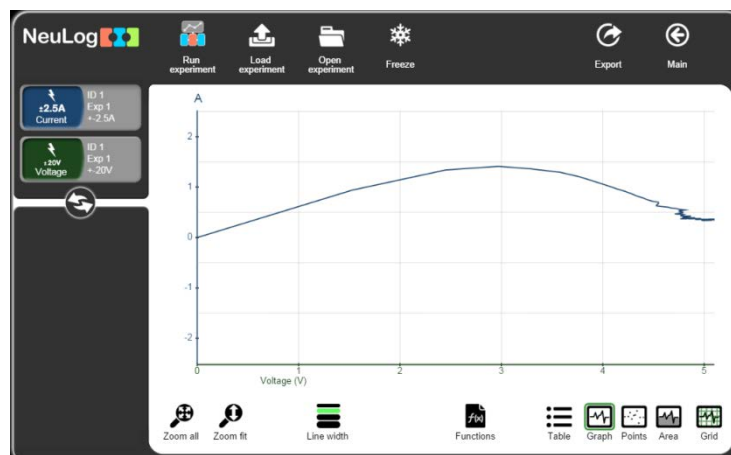
### 3.5.2 Plotting an XY graph

Up until this point, running the experiment resulted in graphs of 'Voltage across the bulb against Time' and 'Current through the bulb against Time' being plotted separately. This done, you can now plot what is known as an **XY graph** with the 'Voltage across the bulb' on the X-axis and the 'Current through the bulb' on the Y-axis.

- Another display option for more than one sensor is to plot the measured results for one sensor along the X axis (instead of time); all the other sensors will be plotted on the Y axis in relation to the X axis. Click on the **Functions** button.
- Click on the **X axis** button and choose the **Voltage** sensor.



- Click on the  button to go to the **Experiment view** screen.



You should now see that you have a graph window displayed with **Voltage** along the X-axis and **Current** along the Y-axis.

The current goes up and then down because the bulb's resistance increases when the bulb's temperature increases.


Alternatively you could plot the graph with Voltage along the Y-axis and Current along the X-axis.


This graph shows us that until 3V the bulb acts as a constant resistance.


The bulb resistance increases and the current goes down when the bulb turns on.

### 3.6 Single step mode

An experiment can be run taking and recording measurements only when you wish to do so.

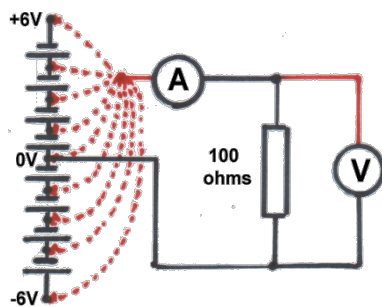
This is known as **Single Step mode** and is accessed from the **Single step**  button. In this mode data will only be collected from the sensor(s) on each click of this button.

This mode is used to measure discontinuously or to measure samples that do not change as a function of Time. For example, to record the temperatures of different soil or sand samples that has been exposed to the Sun for an hour. Simply insert the **Temperature sensor**  rod into each sample in turn and record their temperatures into a table by repeatedly clicking on the

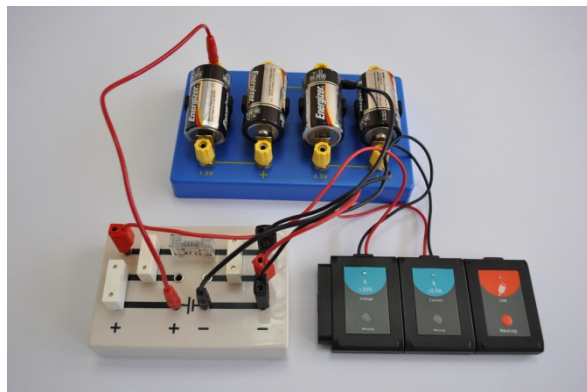
**Single step**  button. A graph of the data would probably not be useful, though if one was plotted its X-axis would be displayed as a Counter (1, 2, 3, 4 etc.). Here the table is more important.

**Single step mode** can be used when you need to collect sensor readings at specific values. You could investigate how the current through a  $100\Omega$  resistor, a diode, a 6V MES filament bulb and a light emitting diode (led), vary with applied voltages of approximately 0V,  $\pm 1.5\text{V}$ ,  $\pm 3\text{V}$ ,  $\pm 4.5\text{V}$  and  $\pm 6\text{V}$ , provided simply by two sets of cell holders. Such a setup does not require a continuously variable voltage supply and therefore it is easier to provide multiple sets for class use. By finally setting up **XY graphs** with the data and overlaying these with a (best-fit) **Linear-fit line**, it can be seen which of the components obeyed **Ohm's Law**. The following instructions are for investigating a  $100\Omega$  resistor.

- Construct the circuit shown in the diagram and photograph below, but leave the red lead (dotted line) from the current sensor to the battery disconnected.

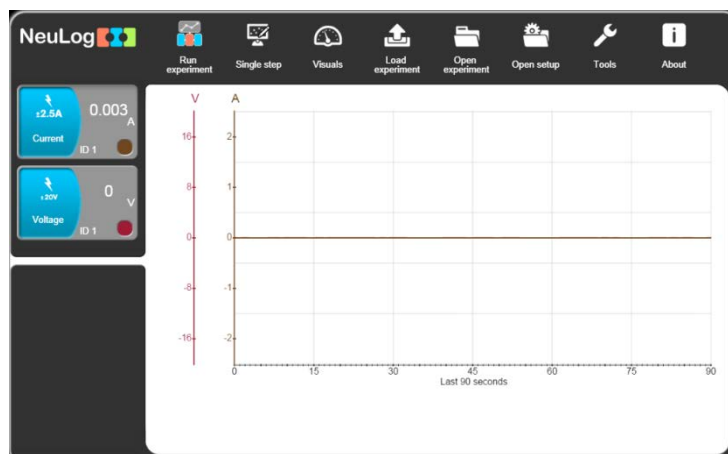


Circuit Diagram




Apparatus Setup

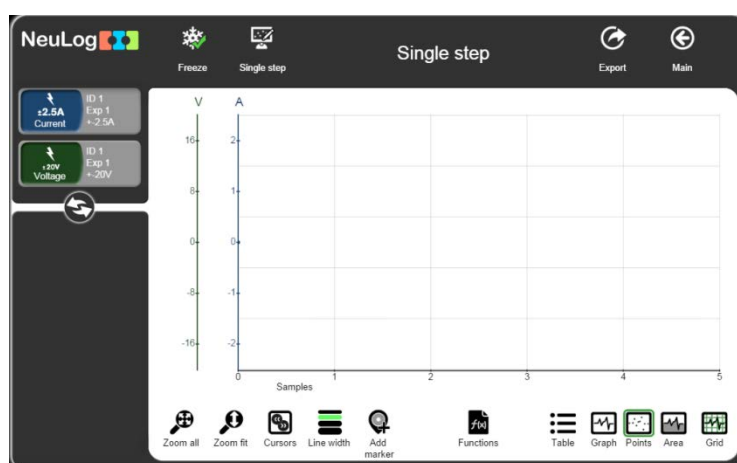
- Open **NeuLog's** main screen. The Voltage and Current sensors boxes are displayed as shown below.



- Connect the Voltage sensor's red plug into the 0V socket of the lower cell holder.

The voltage sensor's box should now display a value around '0V' and the current Sensor's box a value around '0A'.

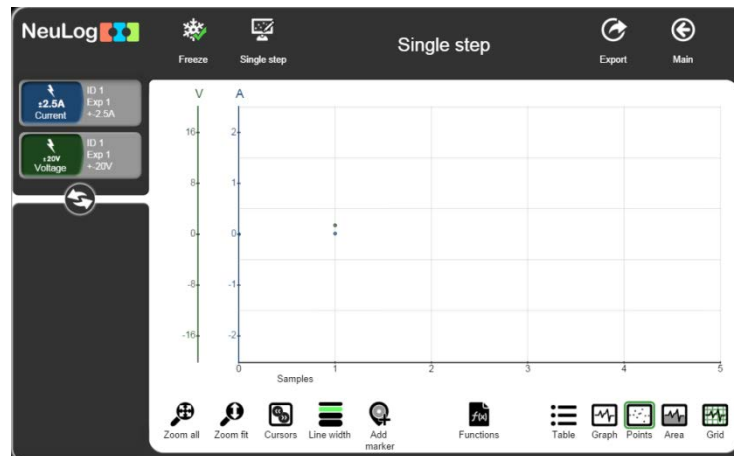
- Click on the **Single step**  button to display the first plot as shown in the Graph window below.




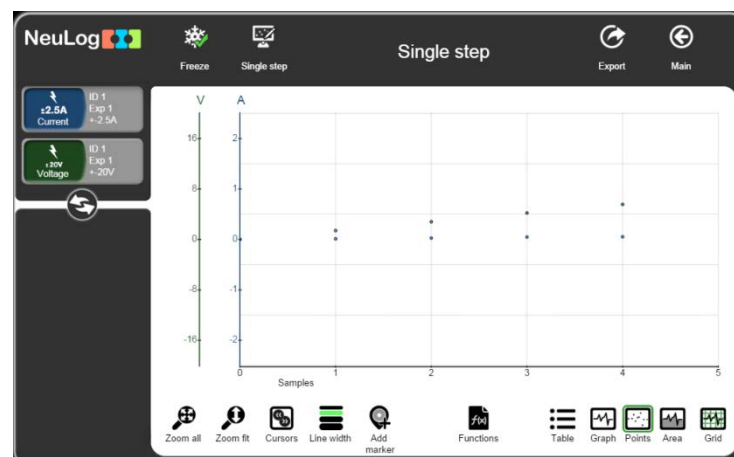
- Now move the voltage sensor's red plug into the 1.5V socket of the lower cell holder.




- Click again on the **Single step**  button.

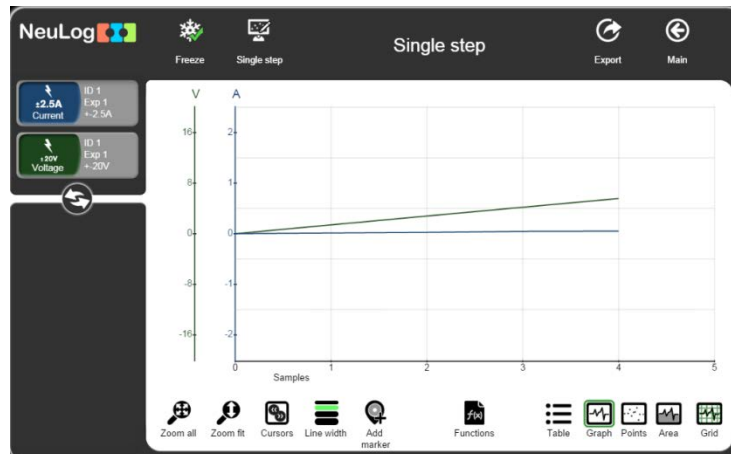


- Repeat the process of moving the Voltage sensor's red plug into the +3V, +4.5V and +6V sockets of the cell holders. Click on the **Single step**  button in the Sub-icon bar after each move.
- You should obtain a graph similar to that shown below:

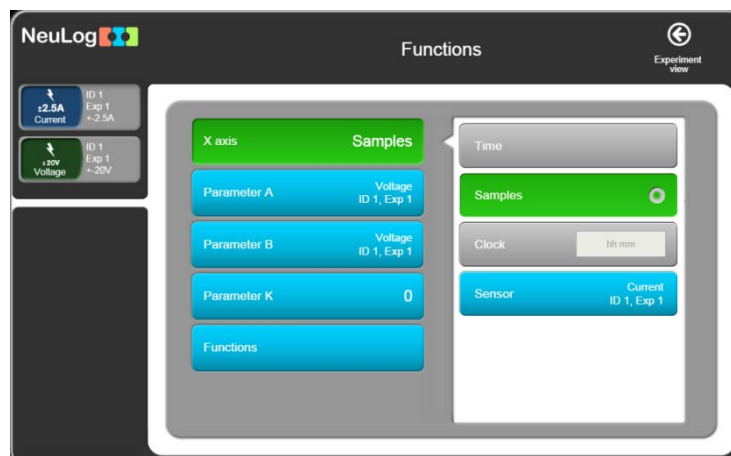


- Remove the voltage sensor's red plug from the 6V socket of the upper cell holder.

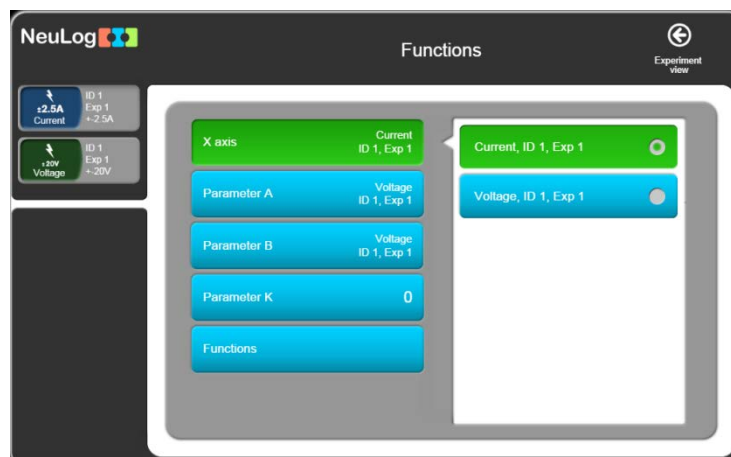
- Click on the **Graph**  button; the dots will be connected by lines.



- Another display option for more than one sensor is to plot the measured results for one sensor along the X axis (instead of time). All the other sensors will be plotted on the Y axis in relation to the X axis. Click on the **Functions** button.

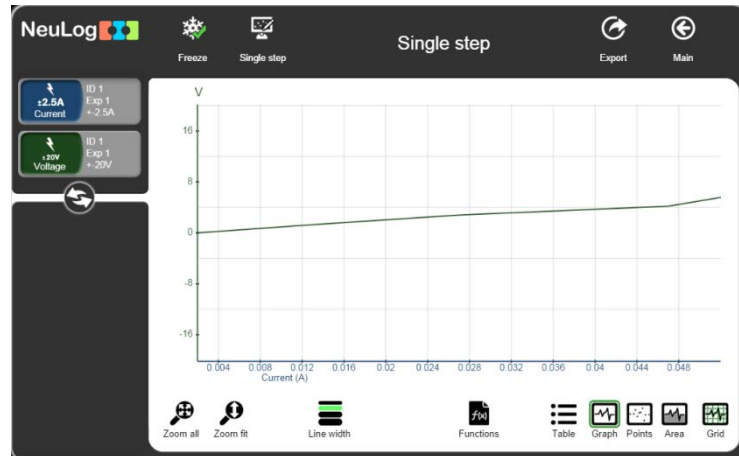


- Note that the X axis is **sample** and not time.
- Change the X axis to the Current sensor.



- Click on the **Experiment view**  button to go back.

You should now see that you have a graph window displayed with **Current** along the X-axis and **Voltage** along the Y-axis.

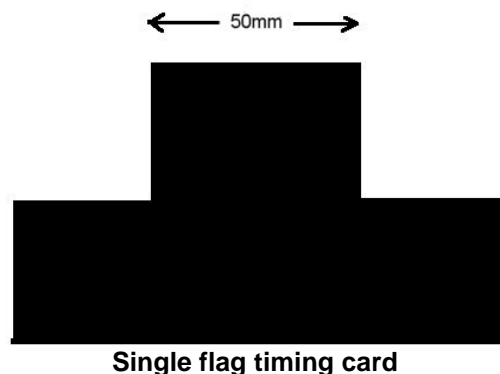
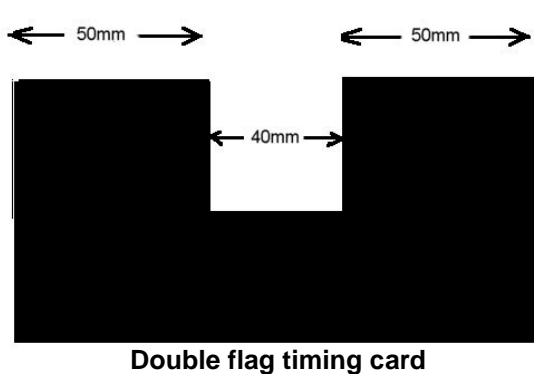


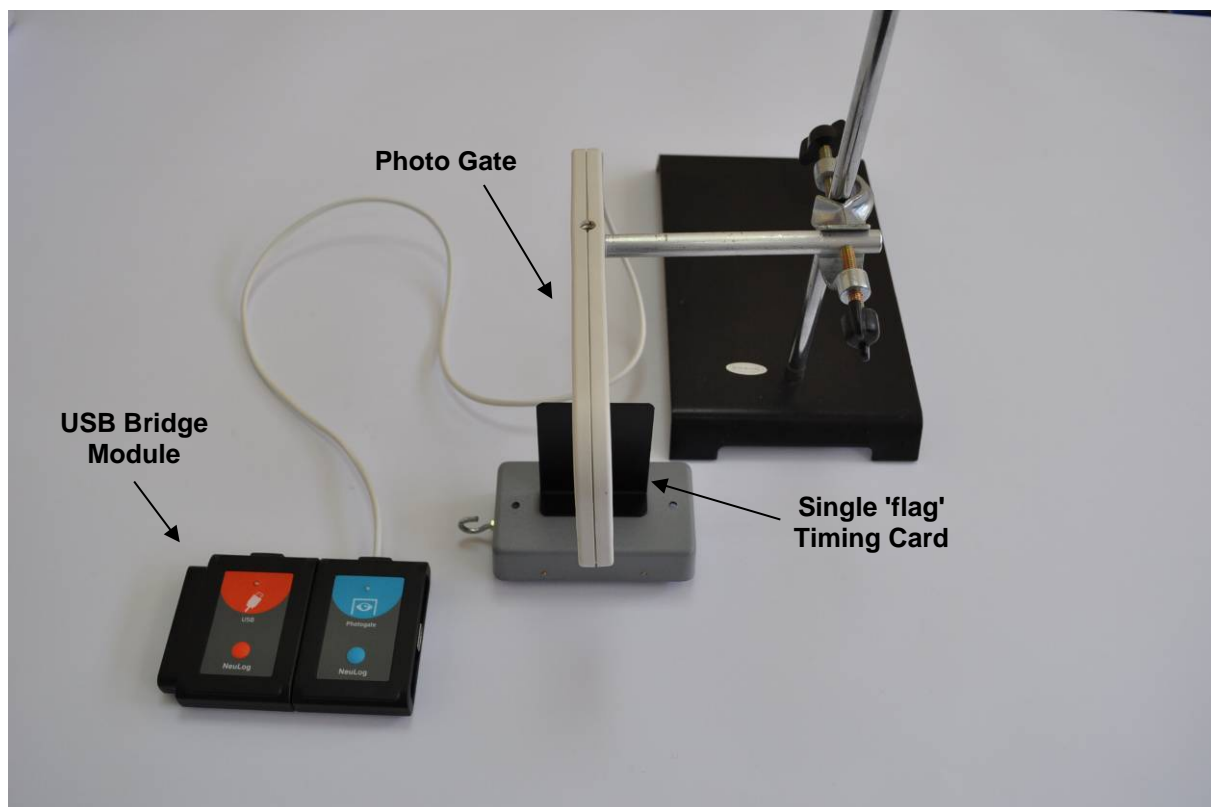
- Click on the **Zoom Fit**  button to expand the graph.



### 3.7 Using photo gates

Photo gates are used to measure the Time for which their infrared beams are interrupted. By inputting the length of timing cards passing through photo gates, both Velocity and Acceleration can be calculated too.

Cut out, as accurately as possible, two timing cards from black plastic card; one with a single 100 mm 'flag' and another with two 50 mm 'flags' separated by a 40 mm gap, as shown below. Cut one more with at least three 'flags' of the same or different size and spacing.

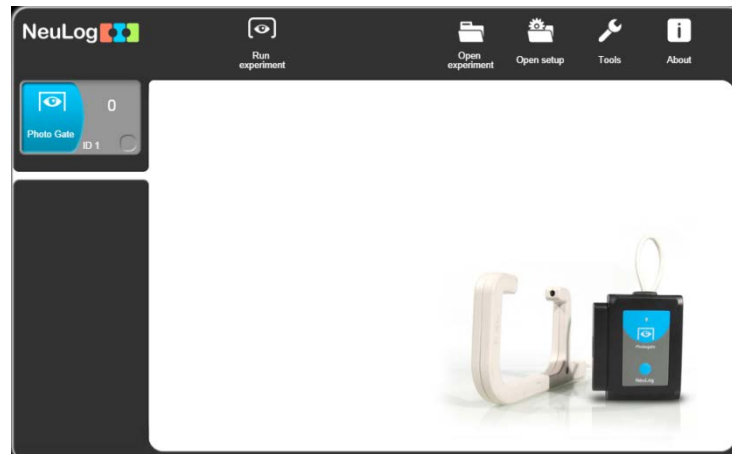





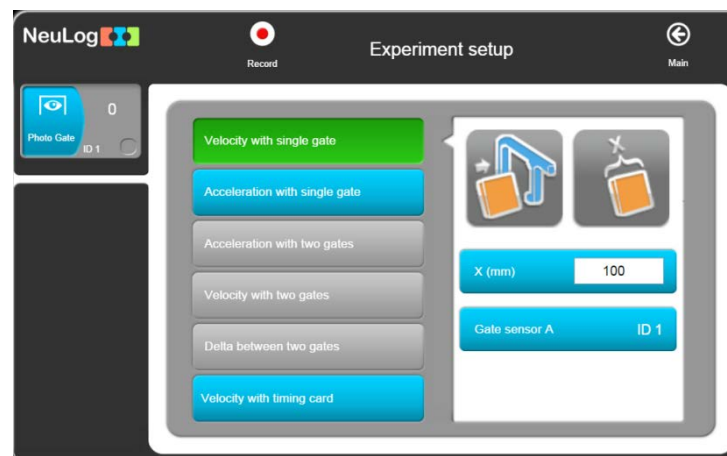
- Attach a Single 'flag' timing card to a model car.
- Place the model car on an approximately 20° sloping runway and temporarily secure it in position.
- Fix a photo gate sensor on a retort stand using a bosshead and position it half-way down the runway so that the timing card will interrupt its beam.
- Connect the **Photo gate sensor**  to the **USB Module** .

The equipment should look like the photograph above.

- Open **NeuLog's** main screen. The Photo gate sensor module box is displayed in the Module window as shown below.




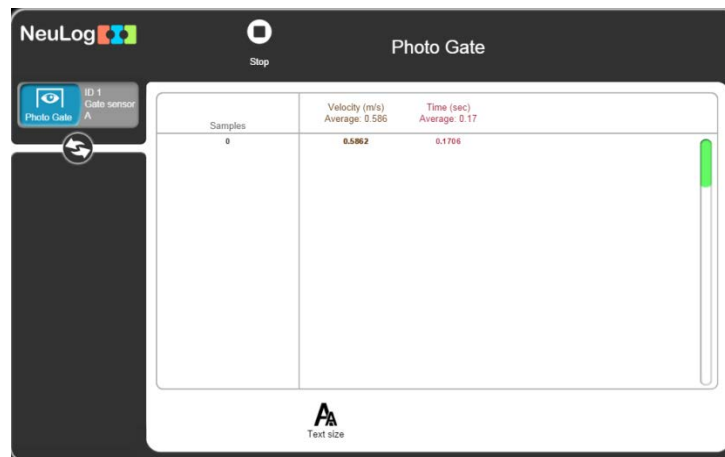
- Click on the **Run experiment**  button and the Photo Gate modes of operation will appear.



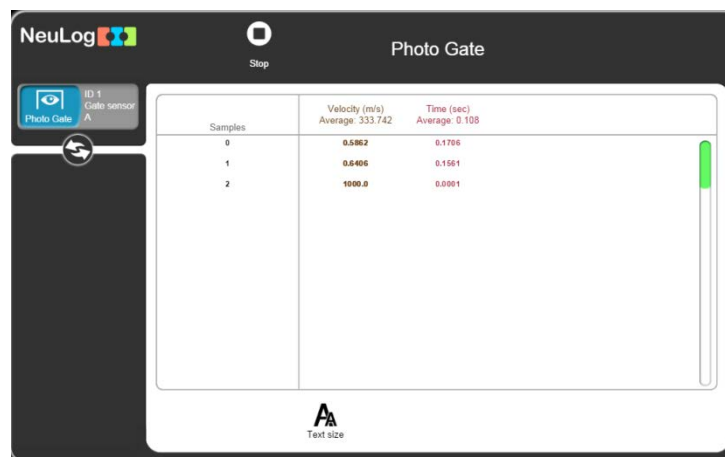
There are three options for experiments with one photo gate: **Velocity with single gate**, **Acceleration with single gate** and **Velocity with timing card**.

### 3.7.1 Velocity with single gate experiment

- Set the flag width (X[mm]) to 100 and click on the **Velocity with Single Gate** button.
- Click on the **Record**  button.
- Mark the release position; let the model car run through the photo gate to display the first measurement in the Table of how long it took the Timing card to pass through it.



- Repeat twice more, releasing the model car from the same position, to obtain a set of measurements similar to those shown below. Note that an average value is provided.



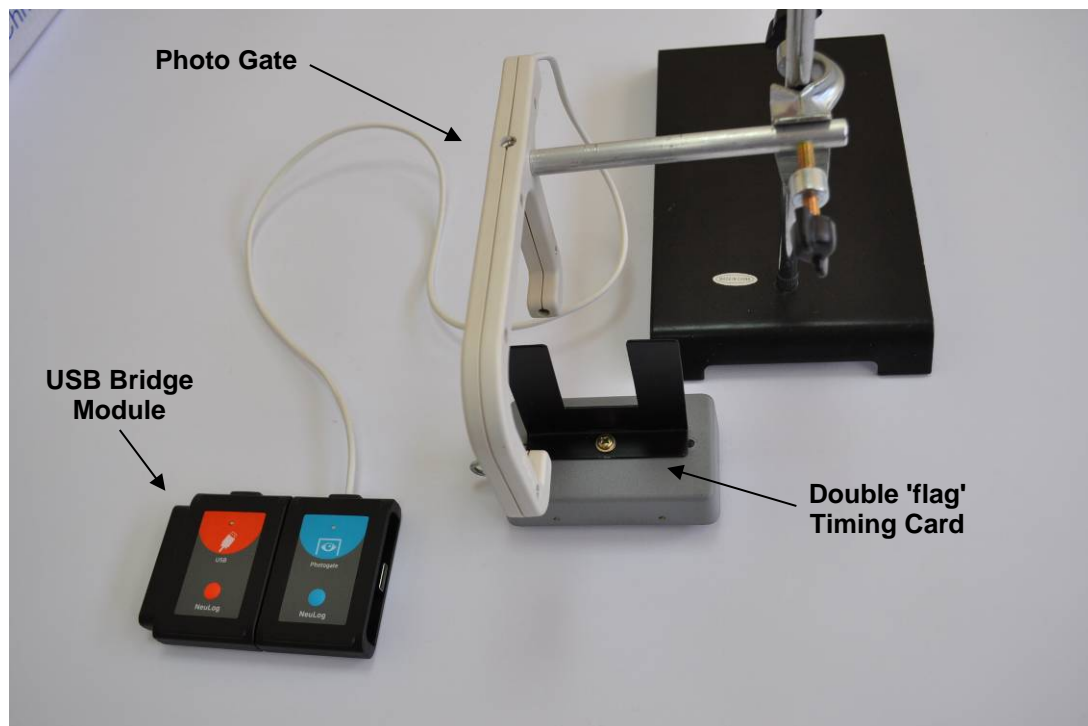
Note that the Table also has velocities recorded as well as times.

The upper line shows the average time and the average velocity of the samples.

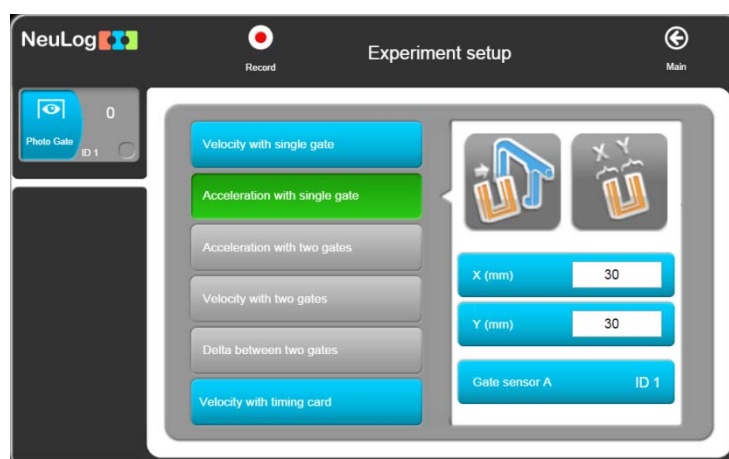
- Click on the **Stop**  button.
- Click on the **Main**  button to go back to the main screen.

### 3.7.2 Acceleration with single gate

The apparatus used here is almost the same as in the Time and Velocity mode, but here a Double 'flag' timing card is used instead of a Single 'flag' card. A photograph of the setup is shown below.



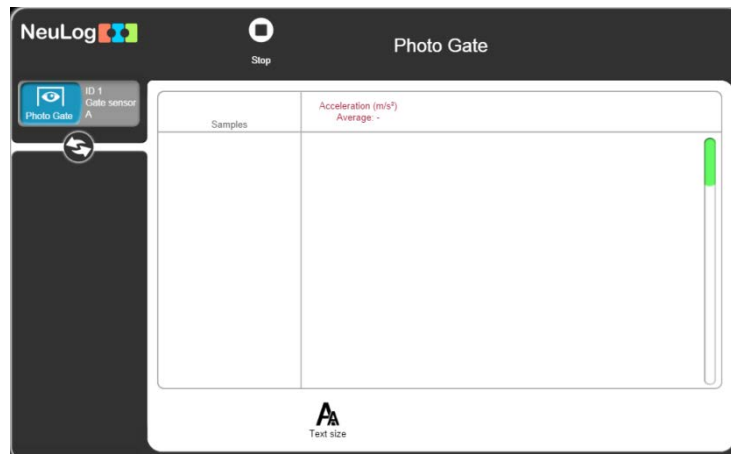
- Attach a Double 'flag' timing card to the model car.
- Click on the **Acceleration with Single Gate** on the **Experiment Setup**.



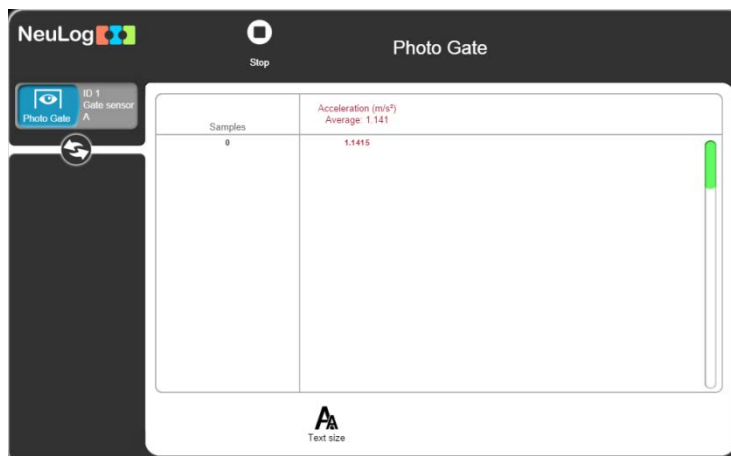
- The system measures the velocity of each flag and divides the difference between the velocities by the time between the flags.

Enter the values '50' as 50 mm is the width of both 'flags'.

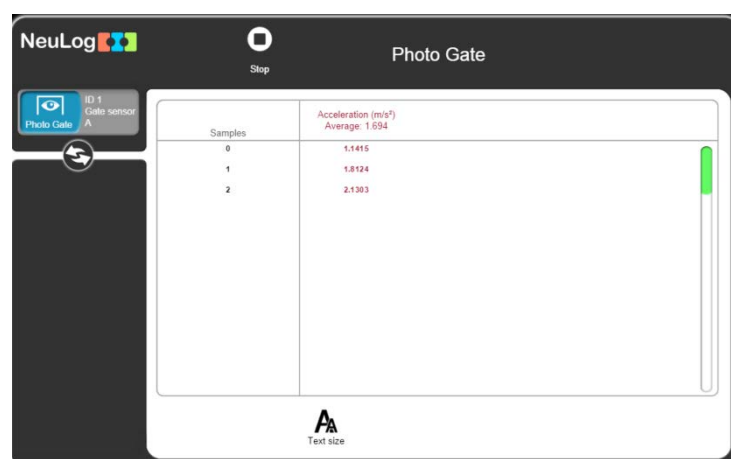
- Click on the **Record**  button.



- Let the model car run through the photo gate to display the first measurement.



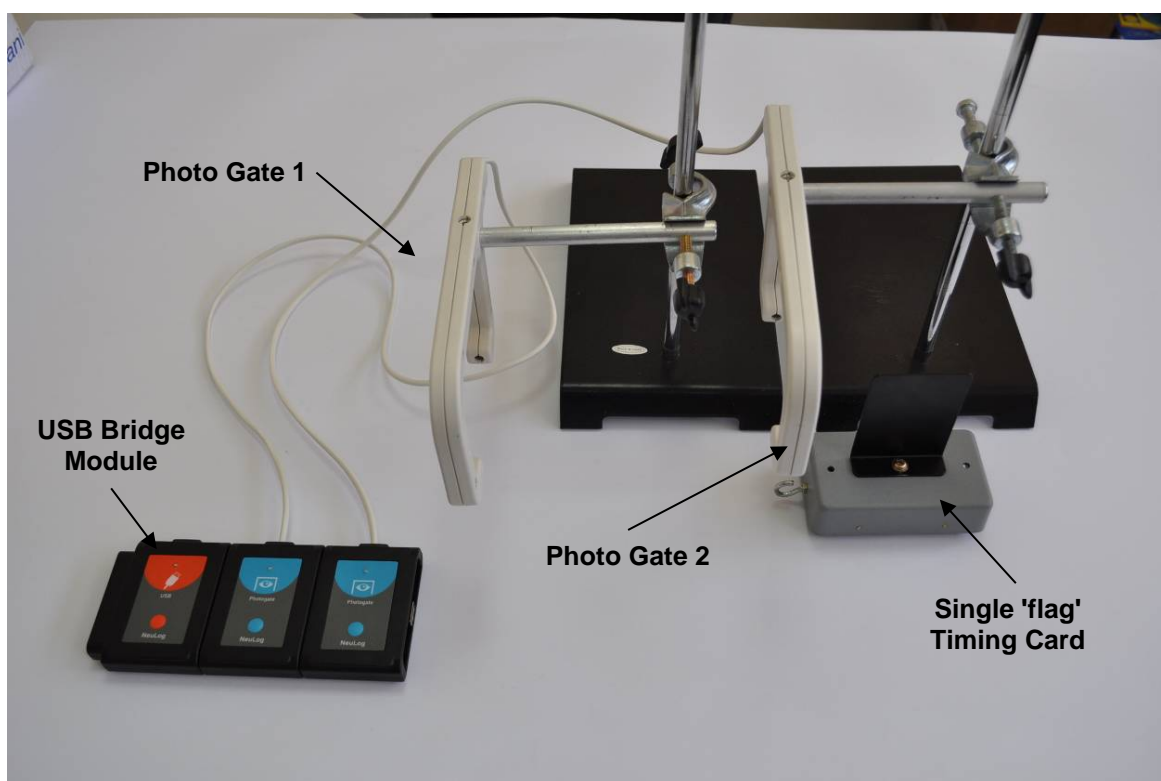
- Repeat **twice** more, releasing the model car from the same position, to obtain a set of measurements similar to those shown below.





- Click on the **Stop**  button.
- Click on the **Main**  button to go back to the main screen.



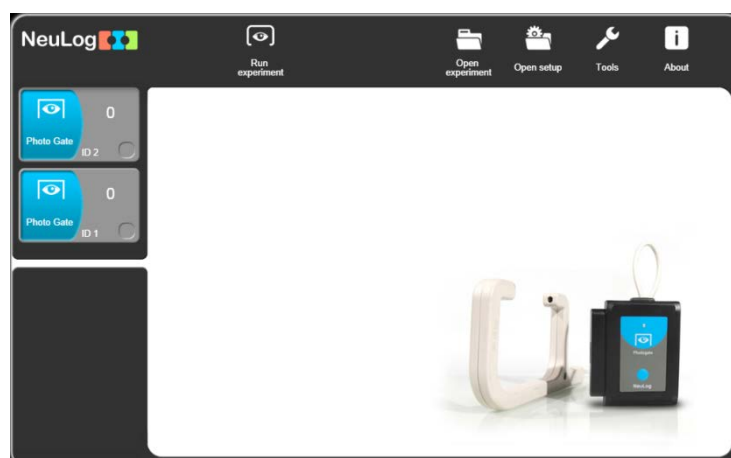
### 3.7.2 Acceleration with two gates experiment




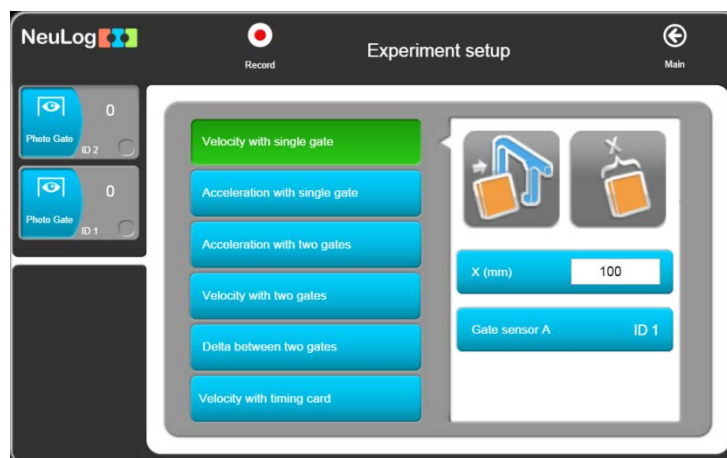
- Replace the Double 'flag' timing card by the Single flag timing card again.
- Connect another **Photo gate sensor**  to the **USB module**  and mount its gate slightly lower down the runway. Again, check that its height is correct for the timing card to break its beam.

The apparatus should look like the photograph above.

- Wait to get the following screen.

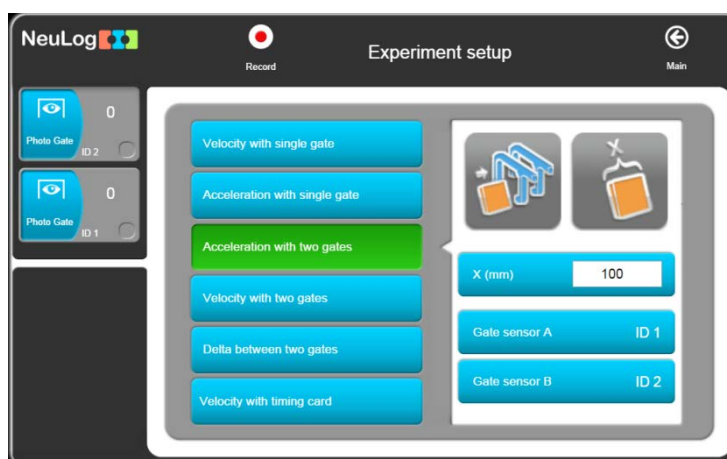


- Click on the **Run experiment**  button and the Photo Gate modes of operation will appear.



All the photo gate options are available here: **Velocity with single gate**, **Acceleration with single gate**, **Acceleration with two gates**, **Velocity with two gates**, **Delta between two gates** and **Velocity with timing card**.

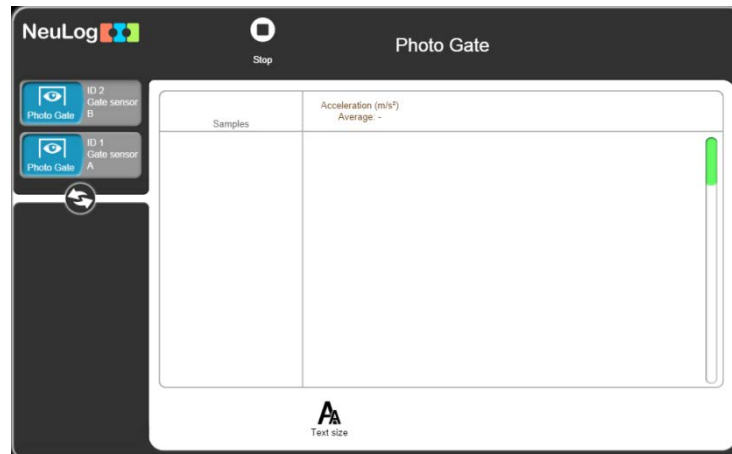
- Click on the **Acceleration with Two Gates** button and set the flag width (X[mm]) to 100.



### **Note:**

When using two identical sensors, as here with two photo gates, it is essential that they have differing Sensor IDs (above they are '1' and '2'). If you find that they have the same ID Number you will need to change one of them as shown in chapter 7, section 7.1. Note also that you need to identify and select in "Choose photo gates' sequence" which photo gate is passed through first and which second. This is most easily done by noting the result of an obvious acceleration which should have a positive value – swap in Sensors IDs if it comes up negative.

- Click on the **Record**  button.



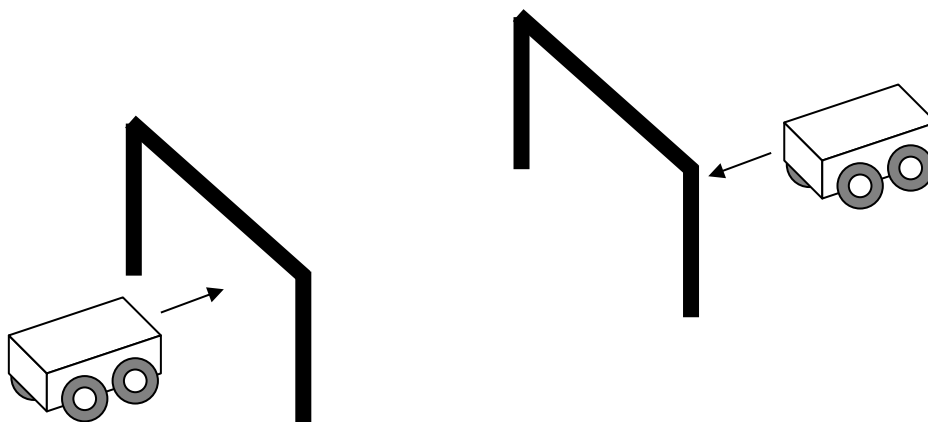
- Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long it took the Timing card to pass through it.
- Repeat twice more, releasing the model car from the same position, to obtain a set of measurements. Note that an average value is obtained.

Note that the Table also has velocities recorded as well as times.

- Click on the **Stop**  button.
- Click on the **Main**  button to go back to the main screen.

### 3.7.4 Velocity with two gates experiment

The apparatus used here is almost the same as in Acceleration with Two Gates, but here two carts are used, moving against each other. A picture of the setup is shown below.



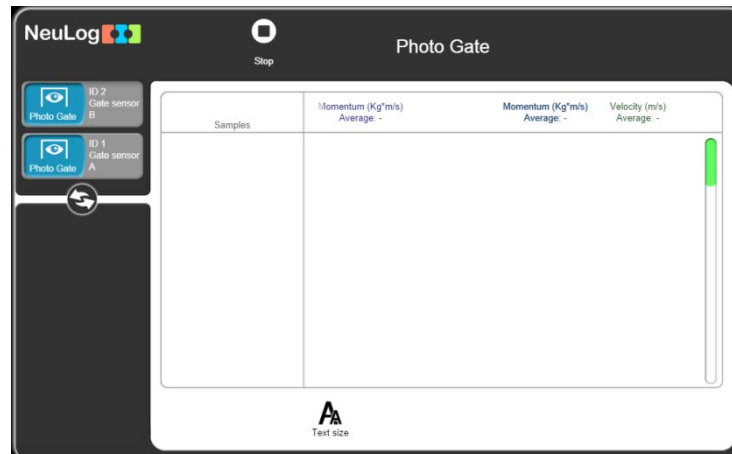
- Attach a 'one flag' timing card to each cart.
- Click on **Velocity with Two Gates** on the **Experiment Setup**.



Observe the fields that open.

- Write the width of each flag and the mass of each cart in these fields.

- Click on the **Record**  button.



- Push two carts against each other so they collide after they pass through the gates and then return again through the gates.

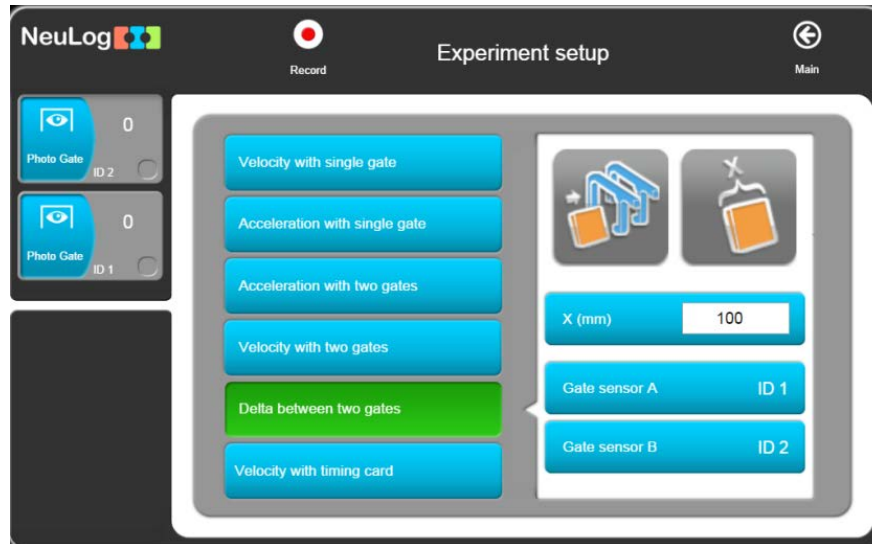
The table shows the velocity and the momentum of each cart before and after the collision.

- Click on the **Stop**  button.
- Click on the **Main**  button to go back to the main screen.

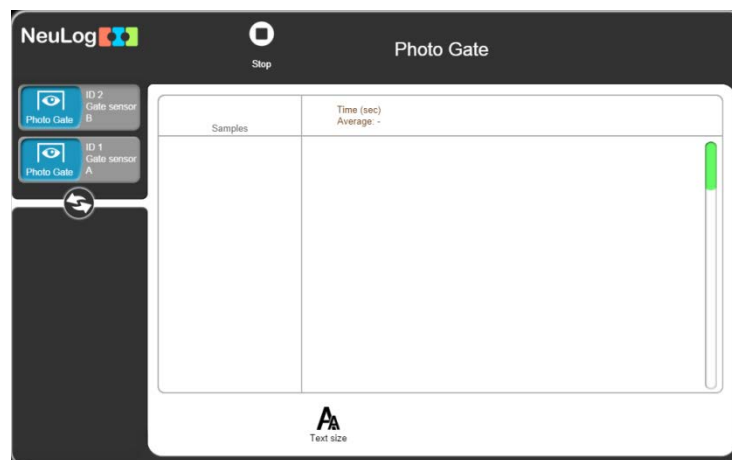
### 3.7.5 Delta between two gates experiment

With the same apparatus shown above, we can measure the time it takes to pass between the two gates.

- Click on **Delta with Two Gates** on the **Experiment Setup**.



- Click on the **Record**  button.



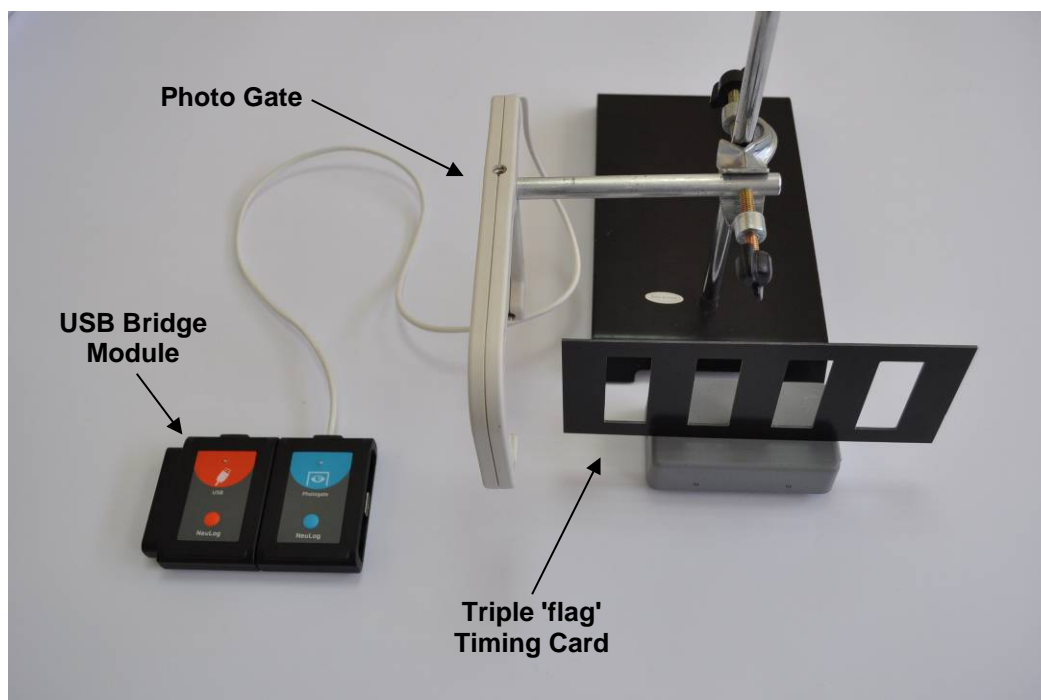
- Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long it took the Timing card to pass through it.
- Repeat twice more, releasing the model car from the same position, to obtain a set of measurements. Note that an average value is obtained.

Note that the Table also has velocities recorded as well as times.

- Click on the **Stop**  button.
- Click on the **Main**  button to go back to the main screen.

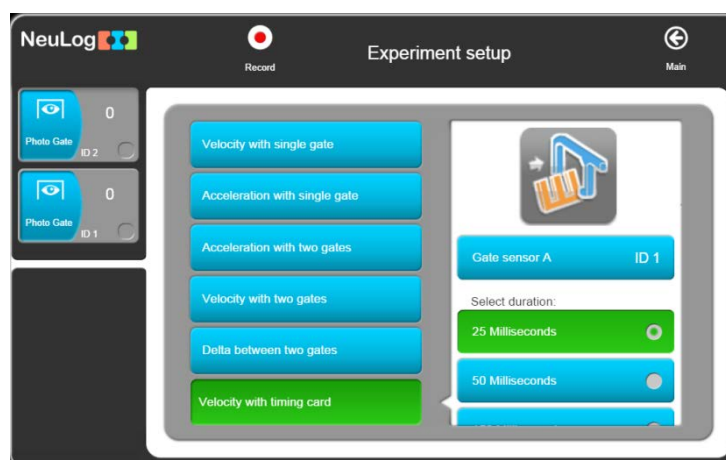
### 3.7.6 Velocities with a timing card experiment

This mode produces a graph showing how the digital status (0 or 1) of the photo gate changes with time as a timing card passes through.



The apparatus setup required now is much like that used for the Time and Velocity mode and is shown in the photograph above.

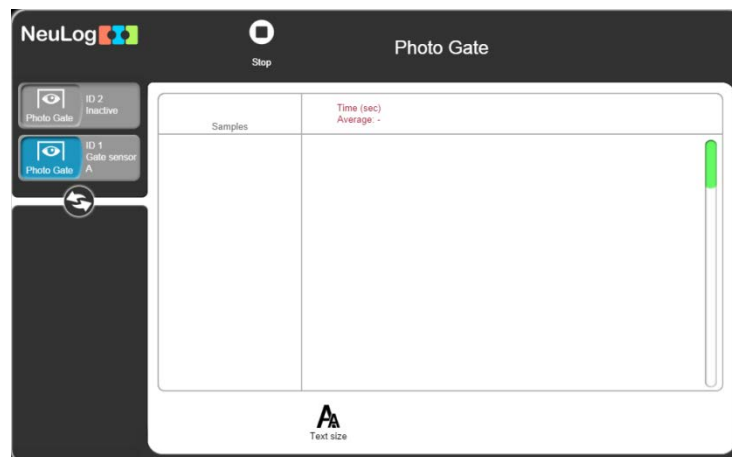
- Although for this experiment we need only one photo gate, both gates can be connected to the USB module. You just have to determine which one is used.
- Attach a Triple 'flag' timing card to the model car.
- Click on **Velocities with Timing Card** on the **Experiment Setup**.








The width of the flags should be 50 mm.

- Select the experiment duration.

- Click on the **Record**  button.



- Run the model car with the multi-flagged timing card through the photo gate to obtain a table with the velocities of each flag.
- Click on the **Stop**  button.
- Click on the **Main**  button to go back to the main screen.
- Disconnect the **photo gate sensor**  from the **USB module**  but leave the **USB module**  connected to the PC.



## Chapter 4 – Off-line Experiment Mode


In this mode the experimental results are not displayed in real-time. The sensors are pre-programmed to perform measurements. The experiment setup, together with the last five data sets, is saved in each sensor's internal non-volatile memory.

**Off-line experiment mode** is when the sensors are programmed connected to an MDU (Monitor Display Unit) with different Sampling rates and Experiment durations. The MDU can be any kind of PC (Windows, MAC, Linux), tablet (IPAD or Android), NeuLog viewer or smart phone.

The sensors are then **disconnected** from the MDU and put into battery-powered chains (or singly) to collect their data on the pressing of the sensors' **Start/stop** buttons. In this mode, each sensor can be programmed independently to be triggered to record data as well as having their **Start/stop** buttons pressed at different times.

Reconnection of the sensors to the MDU is required to upload the data and analyze it. However, all graphs are overlaid on the longest Time axis with  $t=0s$  being where each sensor appears to have been triggered. Hence it does not take into account the time differences between the pressing of any sensors' **Start/stop** buttons and their independent triggering.

At **Off-line experiment mode** the sensors can **remain** connected to the MDU. As before, the sensors can be programmed with different Sampling rates and Experiment durations. Again, each sensor can be programmed independently to be triggered to record data.




To start, click on the **Record**  button (while **Use sensor parameters** is selected) on the PC or by pressing the **Start/Stop** buttons on the sensors, so all the sensors start at the same time.

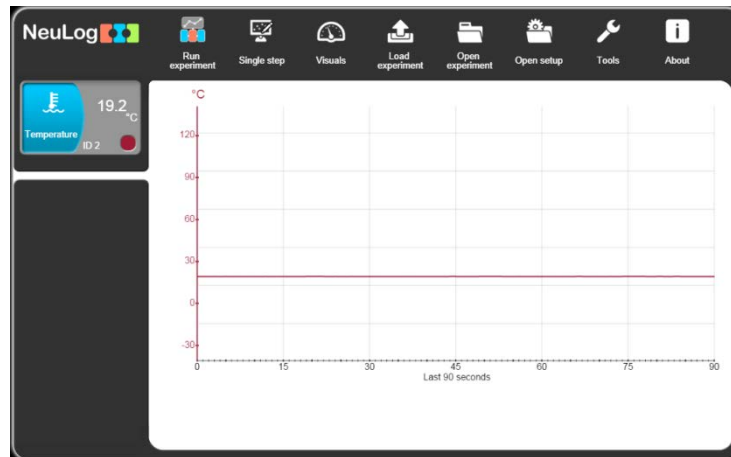
Stop the experiment clicking on the **Stop**  button on the PC or pressing the **Start/Stop** buttons on the sensors. You can wait for the experiment duration to be completed so the experiment ends automatically.

Data is then uploaded for its display and analysis. However, all graphs are overlaid on the longest Time axis with  $t = 0s$  being where each sensor appears to have been triggered.


The activities in this chapter have been designed merely to show how to operate in this mode and its special features.

## 4.1 The off-line experiment mode menu



- Connect the **USB module**  to a USB port on the PC.
- Connect the **Temperature sensor**  to the **USB module** .
- Open **NeuLog**'s main screen to display the following.




## 4.2 Off-line experiment with battery module

In the Off-line experiment mode, you use sensor(s) connected and powered by a **Battery module** . Each sensor can store up to 5 different experiments data.

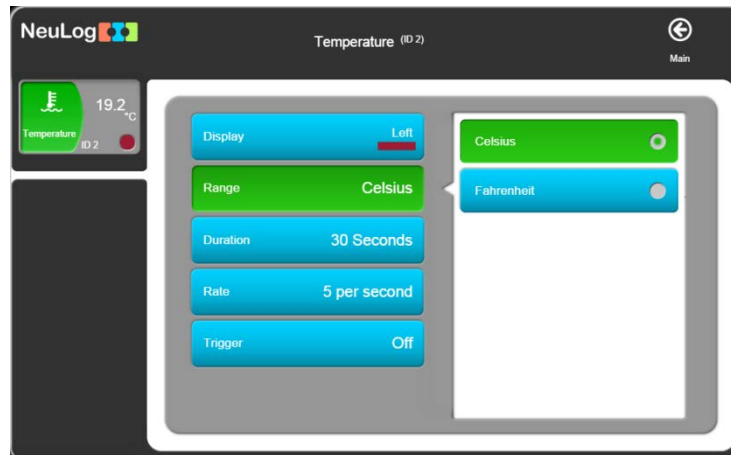
Check first that the module's battery is charged by pressing its button and seeing that the LED alongside turns on. If it does not, then you need to recharge the module.





The **Battery module**  is a battery that can be recharged by connecting it to the PC's USB socket via the **USB module**  USB cable.

The **Battery module**  has a LED and a pushbutton switch. The LED indicates whether the battery is charged enough or not when pressing the pushbutton.

### 4.2.1 Setting up a single sensor without a trigger

- Click on the Temperature Sensor Module box to display the Temperature 1 – Options tab window shown below.






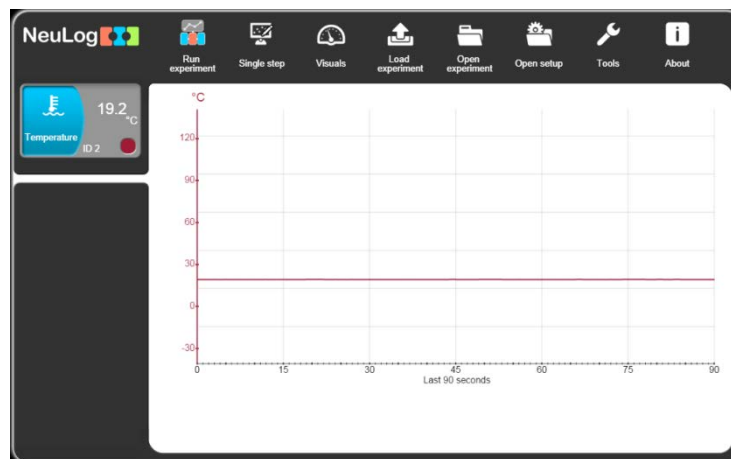
- Check that the **Range** button is set to 'Celsius'. Reset if necessary.
- Set the **Experiment duration** to '30 seconds'.
- Set the **Sampling rate** to '10 per second'.
- In this example the Trigger is **not** being used so the **Trigger** should be **OFF**.
- Click on the **Main**  button to go back to the main screen.
- Disconnect the **Temperature sensor**  from the **USB module**  and plug it into the **Battery module** .
- If you have a digital display module, you can connect it to the chain.

## 4.2.2 Running a single sensor without a trigger

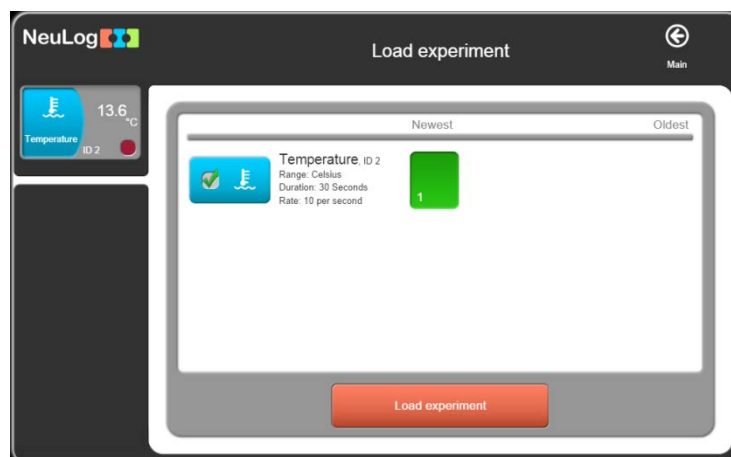
### Note:

**Take care. In this experiment you will use hot water.**

- Pour about 200 ml of hot water at about 60°C into a 250 ml beaker.
- Pour about 200ml of cold water at a temperature below that of the room into another 250 ml beaker.
- Press the **Start/Stop** button on the Temperature sensor. Its red light emitting diode (LED) will blink according to the sampling rate. The sensor will start sampling the temperature 10 times per second for 30 seconds and record the data in its internal memory.
- After about 5 seconds, insert the Temperature sensor's rod into hot water.
- After about a further 10 seconds, take the Temperature sensor's rod out of the hot water and insert it into the cold water.
- After 30 seconds, the red LED will turn **OFF**. Data logging is complete. Pressing the **Start/Stop** button sooner would have also stopped the data logging.
- Remove the Temperature sensor from the cold water.
- Unplug the **Temperature sensor**  from the **Battery module**  and reconnect it to the **USB module** .
- You should have the following screen:

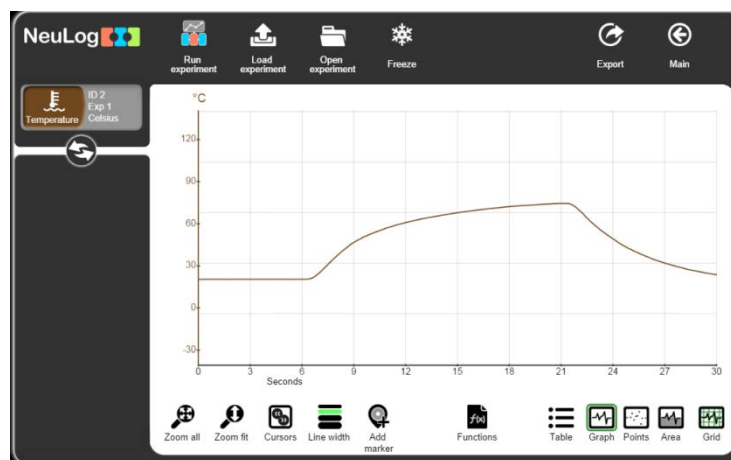


- Click on the **Load Experiment**  button and note the following screen:




A list of experiments stored in the sensor's memory will appear on the screen (up to 5).

- Click on **Newest** on the window, to upload the last stored experiment data and then click on the **Load Experiment** button.
- The sampled data will be uploaded to the PC and a graph similar to that below will be displayed.






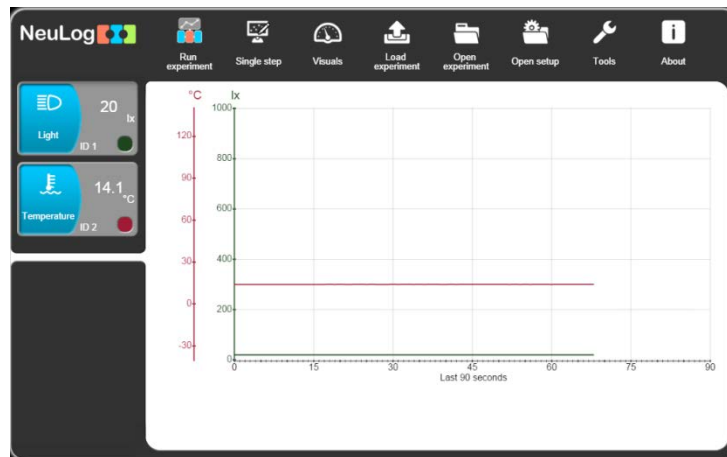
As in the On-line mode, all the various Zoom, cursors, functions, point/line graph, clear experiment results, freeze graph and export to spreadsheet facilities are available via their icons.

You can upload an experiment, freeze it  and upload another one.

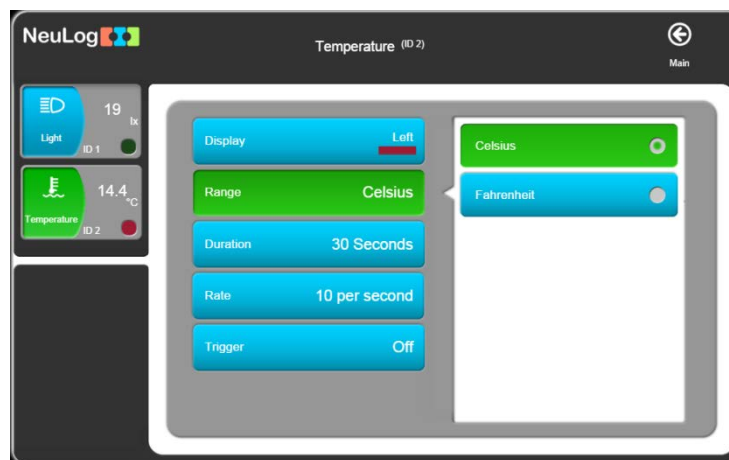
- Click on the **Main**  button to go back to the main screen.
- Leave the **Temperature sensor**  and **USB module**  connected to the PC.


### 4.2.3 Setting up two sensors without triggers

- Additionally, plug the **Light sensor**  to the **Temperature sensor**  or to the **USB module** .
- Go back to the main screen and observe the following screen:






- Click on the Temperature Sensor Module box to display the Temperature 1 – Options tab window shown below.



- Check that the **Range** button is set to 'Celsius'. Reset if necessary.
- Set the **Experiment duration** to '2 minutes'.
- Set the **Sampling rate** to '5 per second'.
- Check that the **Trigger** button is **OFF**.
- Click on the **Main**  button to go back to the main screen.

- Click on the Light Sensor Module box to display the Light 1 – Options tab window shown below.






- Set the **Experiment duration** to '1 minute'.
- Set the **Sampling rate** to '5 per second'.
- Check that the **Trigger** button is **OFF**.
- Click on the **Main**  button to go back to the main screen.
- Disconnect the two sensors from the **USB module**  and connect them to the **Battery module** .

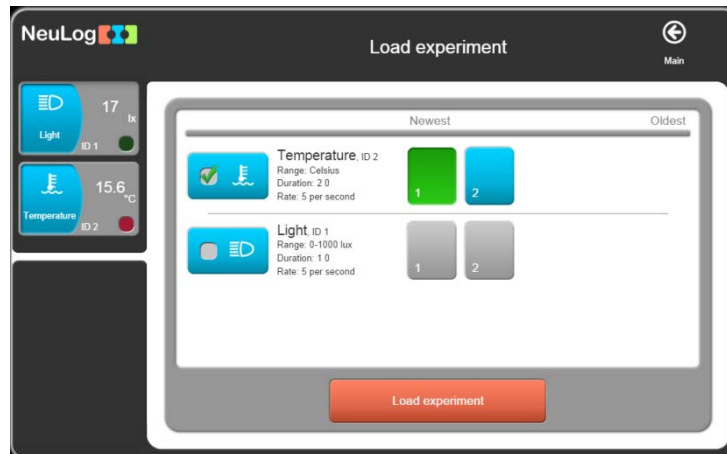
#### 4.2.4 Running two sensors without triggers

##### Note:




**Take care. In this experiment you will use hot water.**

- If not already available, pour about 200 ml of hot water at about 60 °C into a 250 ml beaker.
- Place the Temperature sensor's rod into the hot water and press the **Start/stop** button on the Temperature sensor.
- After about 1 minute press the **Start/stop** button on the **Light sensor**  and move it so that different levels of Illumination are sensed.
- When both LEDs have gone out, disconnect the sensors from the **Battery module**  and reconnect them to the **USB module** .

- Click on the **Load Experiment**  button and note the following screen:



Since the setup of the measurements in each sensor could be different, the software loads them independently.

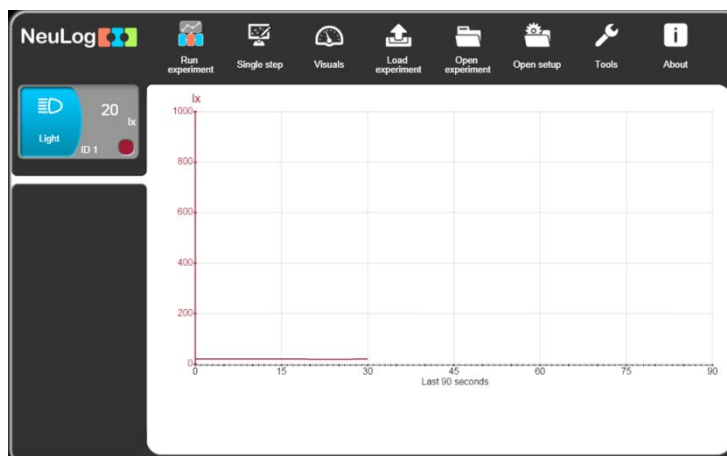
- Click on **Newest**, in the window, to upload the last stored experiment data for each sensor and then click on the **Load Experiment** button.
- Disconnect the **Temperature sensor**  from the chain but leave the **Light sensor**  and the **USB module**  connected to the PC.

#### Note:

The two sensors could also have been programmed and operated separately from each other. Uploading their data subsequently could then have been done (i) separately, in which case only that sensor's data would be displayed on a graph or (ii) both together, in which case both sets of data could be overlaid on the same graph if wished (or indeed uploaded separately).

## 4.2.5 Setting up a single sensor with a trigger

- Go **Back** to the main screen and observe the following screen:








- Click on the Light Sensor Module box to display the Light 1 – Options tab window shown below.



- Check that the **Range** button is set to '1000 lx'. Reset if necessary.
- Set the **Experiment duration** and to '1' second'.
- Set the **Sampling rate** to '100 per second'.
- Click on the **Trigger** button to display the use trigger window.
- Click on the use trigger box.
- Check that the mode is 'Rise'.
- Enter the **Trigger Value** '5'.

The button of the trigger value changes to orange. Click on the trigger value button and its color will change back to blue, indicating that the value was transferred to the sensor.


- Disconnect the **Light sensor**  from the **USB module**  and then reconnect it to the **Battery module** .

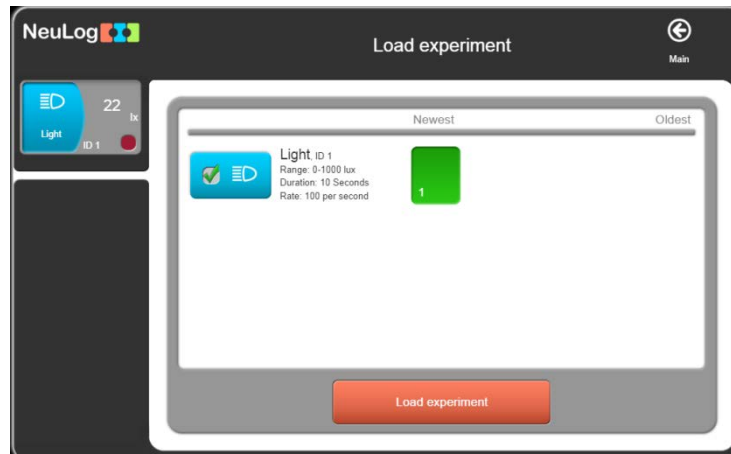
#### 4.2.6 Running a single sensor with a trigger

- Place a finger over the hole on the side of the Light sensor to stop any light from getting in.
- Push the **Start/stop** button on the Light sensor.

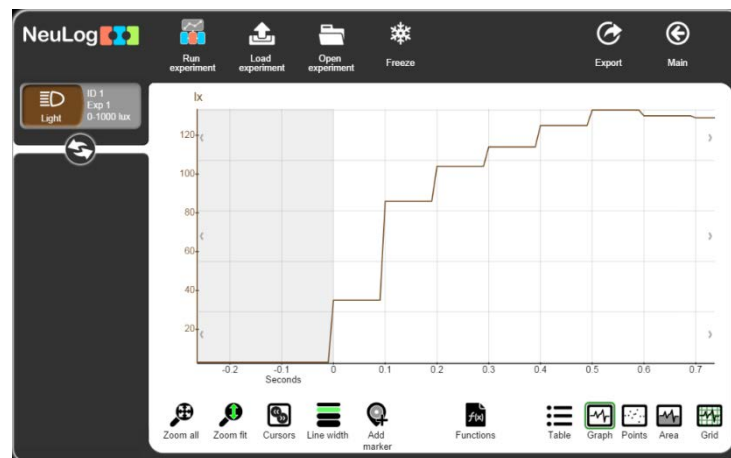
The light sensor LED will blink fast twice with a pause between every two pulses. This means 'Waiting for trigger'.

- Point the sensor's access hole towards the light and then remove your finger from the hole.
- The blinking will stop.





- Disconnect the **Light sensor**  from the **USB module**  and then reconnect it to the **Battery module** .
- Click on the **Load Experiment**  button and note the following screen:

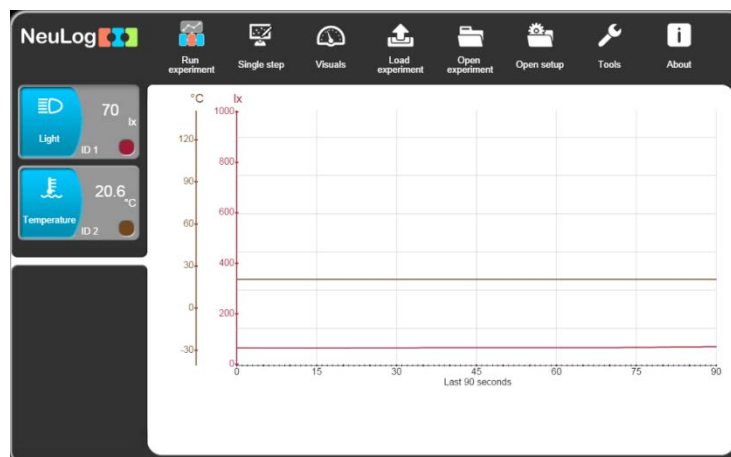


- Click on **Newest**, in the window, to upload the last stored experiment data and then click on the **Load Experiment** button.
- Observe the graph and the pre-trigger area too.

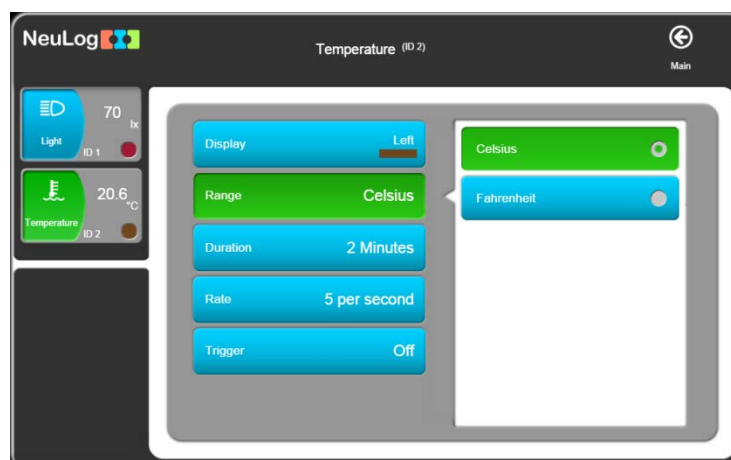


## 4.2.7 Setting up two sensors with triggers

- Connect a **Temperature sensor**  to the **Light sensor**  or to the **USB module** .
- Click on the **Main**  button to go back to the main screen.

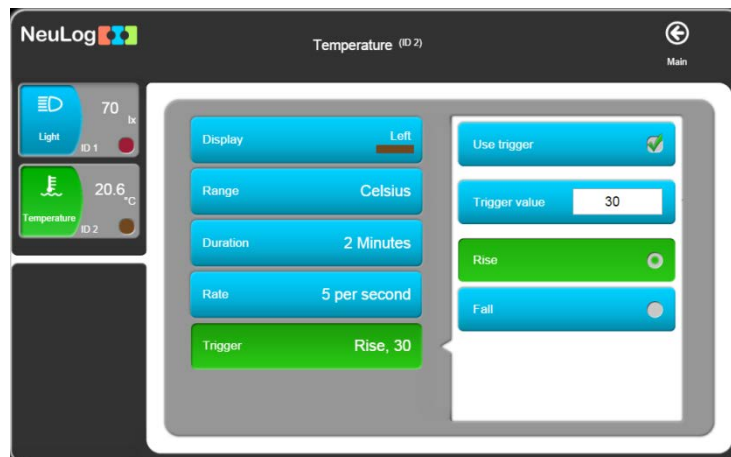


- Click on the Temperature Sensor Module box to display the Temperature Options window shown below.



- Check that the range button is set to **Celsius**. Reset if necessary.
- Set the **Experiment duration** to '2 minutes'.
- Set the **Sampling rate** to '5 per second'.
- Set the **Trigger** to 30 and **Rise**.

- Your screen should look as follows:








- Click on the Light Sensor Module box to display the Light 1 Options window shown below.



- Check that the range button is set to **1000 lx**. Reset if necessary.
- Set the **Experiment duration** to '1 second'.
- Set the **Sampling rate** to '100 per second'.
- Set the **Trigger** to '5' and **Rise**.
- Your screen should look as follows:







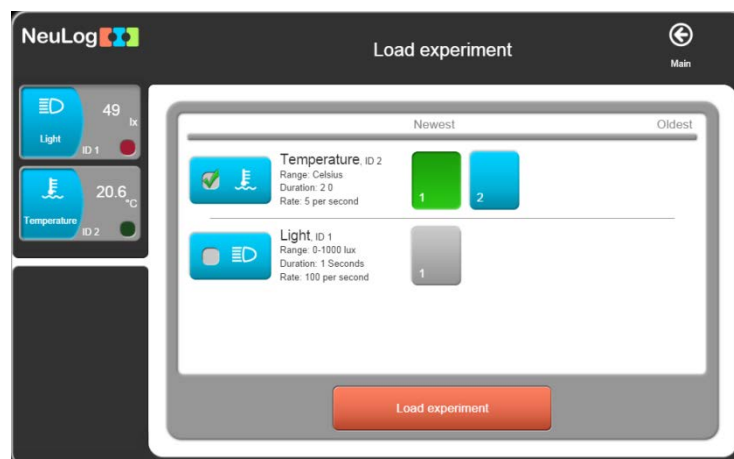
- Click on the **Main**  button to go back to the main screen.
- Disconnect the **Temperature sensor**  and **Light sensor**  from the **USB module**  and connect them to a **Battery module** .

## 4.2.8 Running two sensors with triggers

### Note:

**Take care. In this experiment you will use hot water.**

- If not already available, pour about 200 ml of hot water at about 60 °C into a 250 ml beaker.
- Also pour about 200 ml of cold water into another 250 ml beaker.
- First place the Temperature sensor's rod into the cold water and press the **Start/stop** button on the Temperature sensor.
- After about 1 minute press the **Start/stop** button on the **Light sensor**  and move it so that different levels of Illumination are sensed.
- When the LED on the Light sensor has gone out move the Temperature sensor's rod into the hot water.
- When both LEDs have gone out, disconnect the sensors from the **Battery module**  and reconnect them to the **USB module** .
- Click on the **Load Experiment**  button and note the following screen:



Since the setup of the measurements in each sensor could be different, the software loads them independently.





- Click on **Newest**, on the window, to upload the last stored experiment data for each sensor and then click on the **Load Experiment** button.

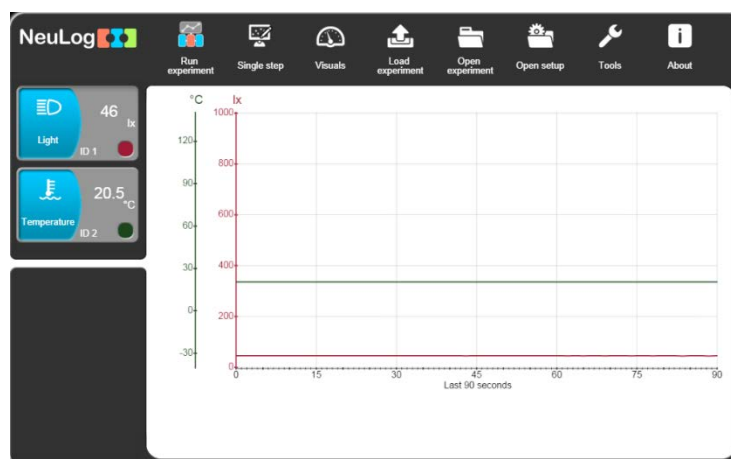
## 4.3 Off-line experiment mode with a PC

We shall repeat the experiment two sensors without triggers with the PC. Instead of pressing the **Start/Stop** button on each sensor, we shall operate the sensor from the PC.

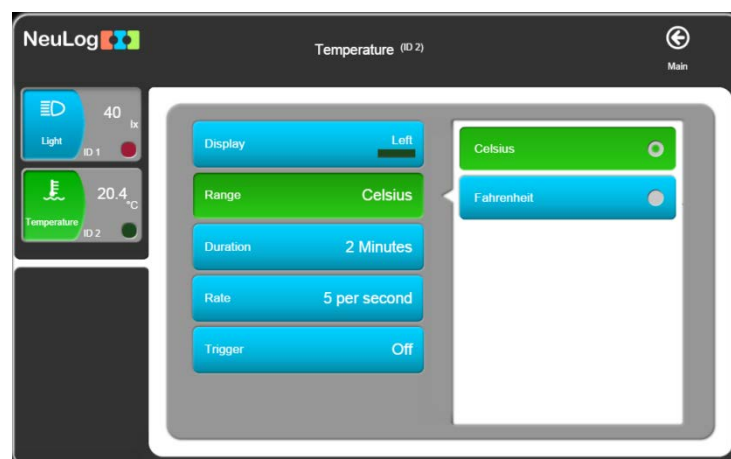
This experiment can be done with any type of MDU.

### 4.3.1 Setting up two sensors without triggers

- Plug the **Temperature sensor**  and the **Light sensor**  to the **USB module** .
- Click on the **Main**  button to go back to the main screen.




- Click on the Temperature Sensor Module box to display the Temperature 1 – Options tab window shown below.



- Check that the Range button is set to **Celsius**. Reset if necessary.
- Set the **Experiment duration** to '2 minutes'.
- Set the **Sampling rate** to '5 per second'.
- Set the **Trigger** button to **OFF**.

- Click on the Light Sensor Module box to display the Light 1 Options window shown below.



- Set the **Experiment duration** and to '1 minute'.
- Set the **Sampling rate** to '20 per second'.
- Set the **Trigger** button to **OFF**.
- Click on the **Main**  button to go back to the main screen.

Both the Temperature and Light sensors have now been setup.


**Note:**

Leave both of the sensors connected to the PC via the USB .

### 4.3.2 Running two sensors without triggers

**Note:**

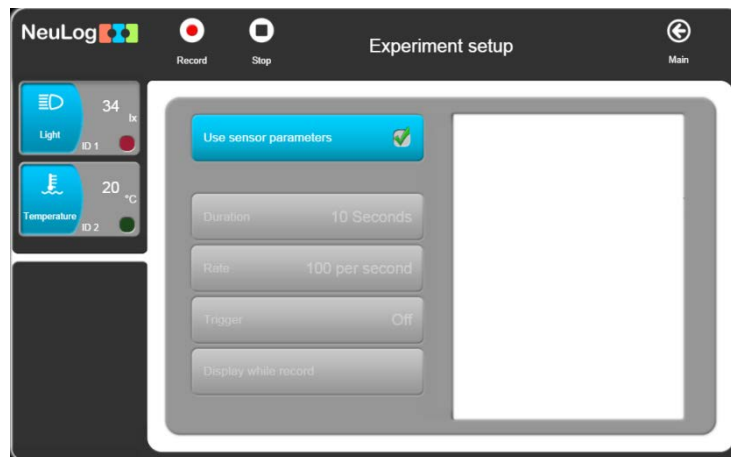
**Take care. In this experiment you will be using hot water.**


- If not already available, pour about 200 ml of hot water at about 60 °C into a 250 ml beaker.
- Similarly, pour about 200 ml of cold water at a temperature below that of the room into another 250 ml beaker.
- Place the Temperature sensor's rod into the hot water.
- Click the **Run Experiment**  button.

**Note:**

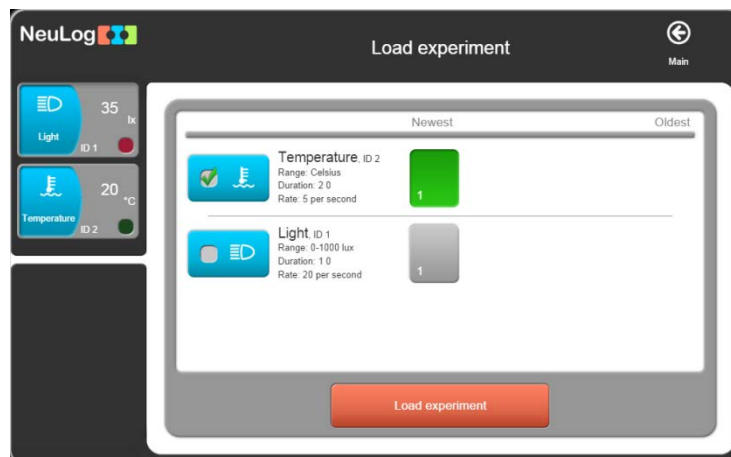
**This button enables us to run an off-line experiment at the same time.**

- Select the **Use sensor parameters** button.





- Click on the **Record**  button; the two sensors will start sampling at the same time but with different experiment parameters.
- Direct the light sensor to a light source and to the ground alternately.  
Pay attention to the two different rates of blinking because of the two different rates of sampling.
- When the light sensor stops blinking after one minute, move the temperature sensor's rod to the cold water.
- Wait until the temperature sensor stops blinking too.

- Click on the **Load Experiment**  button and note the following screen:



Since the setup of the measurements in each sensor could be different, the software loads them independently.

- Click on **Newest**, on the window, to upload the last stored experiment data for each sensor and then click on the **Load Experiment** button.
- Disconnect both the **Light sensor**  and the **Temperature sensor**  from the **USB module**  and unplug the latter from the PC.



# Chapter 5 – Using the RF Communication Modules

## 5.1 RF with a PC

For wireless communication between a single sensor, or chain of sensors, and a PC, simply plug the sensor(s) **and** RF Communication module into a Battery module. Then, at the PC end, plug another RF Communication module into the USB module with the latter plugged into a PC. Communication is then as if the sensor(s) were connected directly.

Any kind of PC (Windows, MAC, and Linux) may be used.

The sensors can be connected wirelessly to tablets through Wi-Fi.

The RF module has an ID number. Two RF modules that communicate with each other should have the same ID number.

The setup of the RF module ID number is explained in section 6.1.

**Note:**

**The PC does not require any Wi-Fi™ or Bluetooth™ installation.**





## 5.2 RF with a PC and groups of sensors

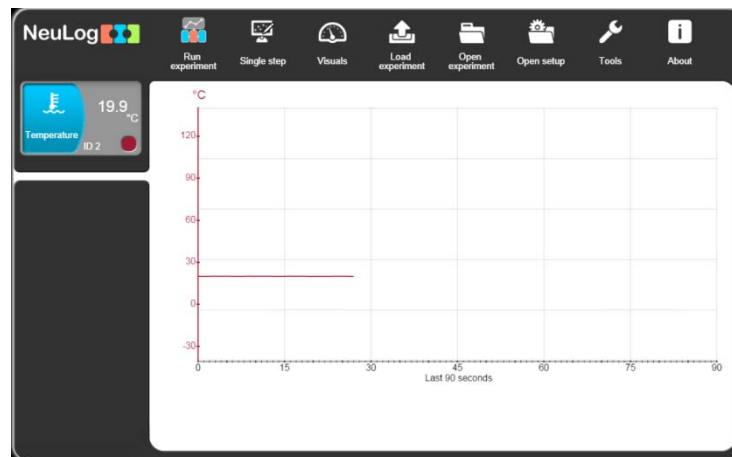
We can use one PC with up to nine groups of sensors operated as described in section 5.1.

The RF module connected to each group of sensors and battery module should have a different ID number.

The PC can address one group at a time by setting the ID number of the PC's RF module to the required group's RF module ID number.

## Chapter 6 – Tools

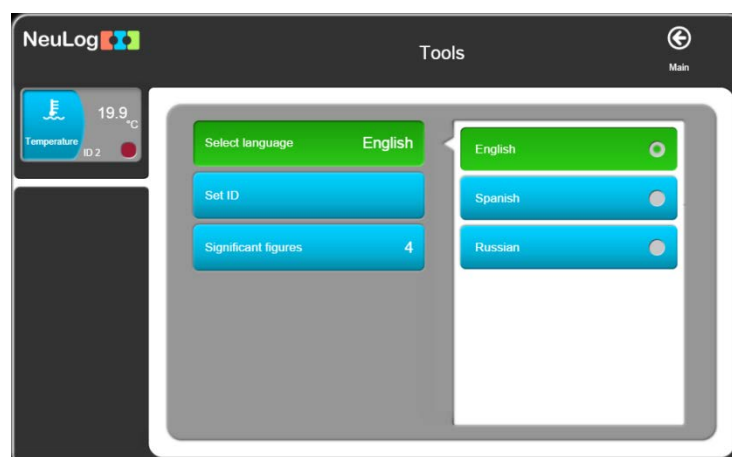
- Connect the **USB module**  to a USB port in the PC.
- Connect the **Temperature sensor**  to the **USB module** .
- Double-click on the NeuLog  icon on your desktop to display the following:



The Logger Sensors software has several tools through which a sensor's ID and software language can be changed.

Another important tool saves an experiment's configuration.

- Click on the **Tools**  button to display the following screen:



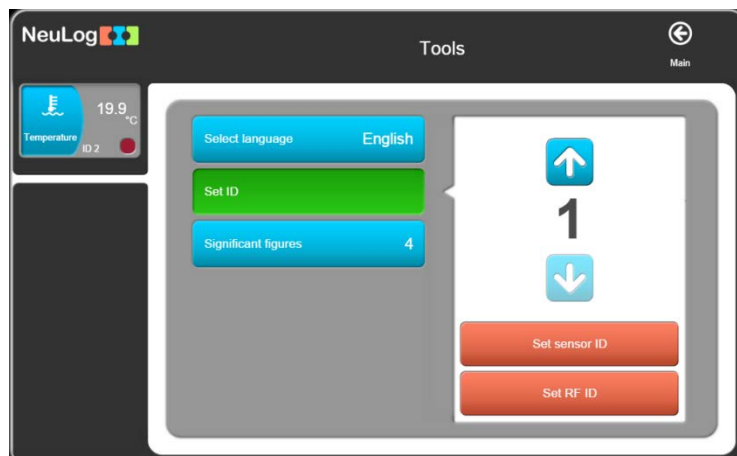
The **Select Language** button allows changing the language used by the software.

## 6.1 Set sensor and RF module ID number

- The **Set Sensors ID** allows us to modify the ID for all of the sensors connected to the system according to the key pressed (1 to 9). After pressing 1 to 9, an automatic search will start.

**Note:**

When connecting more than one specific sensor, each sensor must get its own ID number.



- Set the **number 2** and click the **Set Sensors ID** button. The sensor will get the instruction to change its ID to '2'.

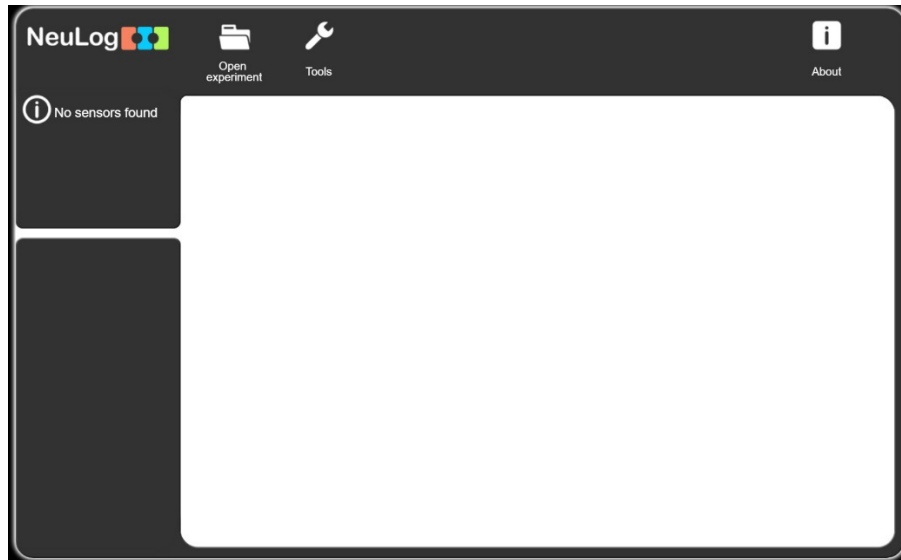
The **Search** function will run automatically and you will see that the sensor's Module box in the Module window now shows '2'.


- Repeat the above steps and return the sensor's ID number back to '1'.

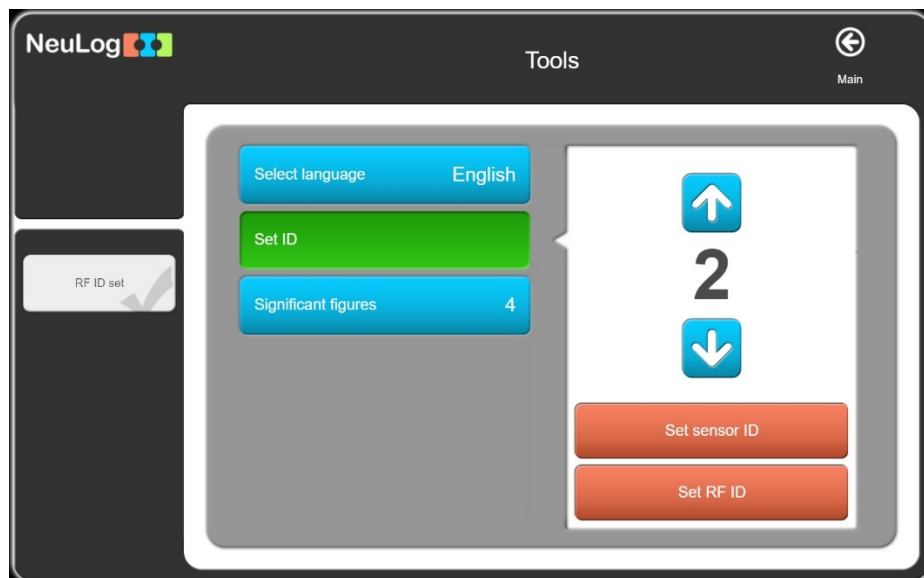
Setting a number in the box alongside the **RF icon** and then clicking on the **RF icon** will change all the connected RF modules IDs to this number. Here you will just deal with one RF module.

- Connect one RF module to the USB module and check that no other RF module is connected to a battery module.

When connecting a RF module to the USB module, the message **No sensors found** appears on the left. It does not mean that the software didn't recognized the module



- Click on the **Tools**  button and then click on the **Set ID** button.
- Use the arrows to choose the number 2 and click on the **Set RF ID**.

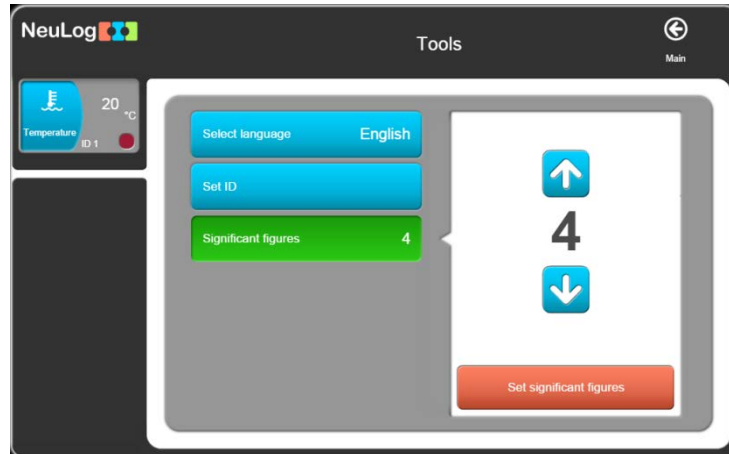


The message **RF ID set** will appear on the left.

- Repeat the above steps and change another RF module ID.

## 6.2 Significant figures

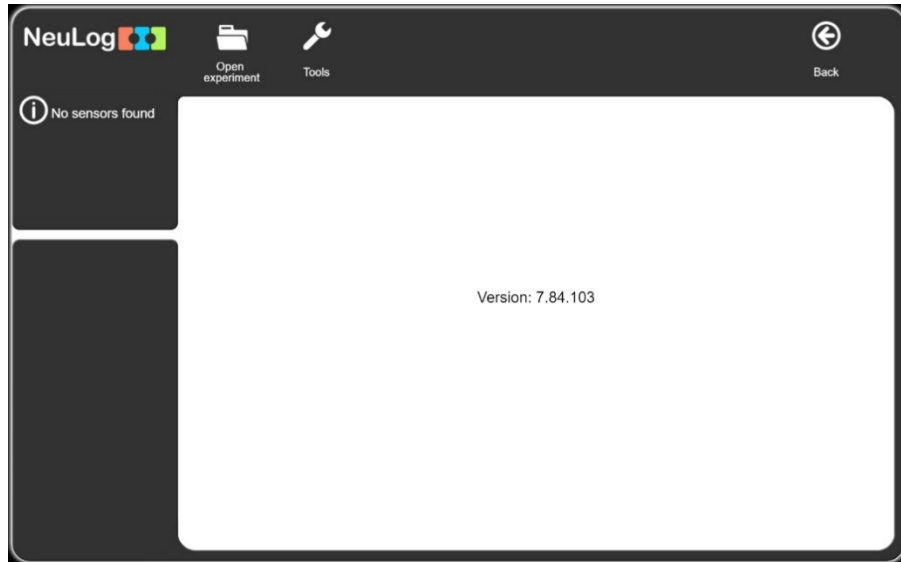
The **Significant figures** button defines the number of digits that the software will display. For example, if the number of significant digits is 4, then the number 5.4321 will be displayed as 5.432 and the number 54.321 will be displayed as 54.32. This scheme allows us to maintain the level of accuracy in the system.



## 6.3 The About button



The **About** button displays the software version. This information is important when requesting technical support from the factory.



# Chapter 7 – Logger Sensors Modules

This chapter deals with details of the Logger Sensors and associated modules and their special features.

A sensor's **Operating Range** is denoted by the **Y max** and **Y min** values specified.

The **Sampling Rates** of the sensors cover two ranges: (i) from 10,000 samples per second to 1 per hour and (ii) from 100 samples per second to 1 per hour. Not all sensors can be sampled at fast rates as some do not respond quickly. In **On-line Experiment** mode all the modules connected together will automatically run at the same rate, but in **Off-line Experiment** mode they can operate at differing rates.

The **Experiment Duration** should be set by the user; whilst these are most often quite short, they could also be long (many days).

**Sampling Rates** and **Experiment Durations** are interdependent and so, for very fast rates, only short durations are available. The combination of fast rates and long durations is limited by the memory storage capacity of the modules.

## 7.1 USB module

This module enables a fast connection of the sensors to any type of PC with USB port.

The USB module is the first in a chain of sensors connected to a USB port of the PC. It provides both power from the PC to the sensors and communication between the PC and the sensors.

The connecting to the PC is done by using a standard USB – mini-USB connecting cable (camera cable). Such a cable comes with the USB module.

## 7.2 Battery module

The Battery module supplies power to a sensor, or chain of sensors, operating in the off-line mode, to sensors connected to a RF Communication module and to the SENSE Robotics family.

The Battery module is a rechargeable battery module that can be recharged by connecting it to the PC's USB socket via the included USB cable.

The Battery module has a 3 colors LED: Red when charging the battery; Green when the charging is completed; Orange when current is consumed from the battery.

## 7.3 Bluetooth module

The Bluetooth module connects a sensor or chain of sensors to a tablet, iPad or a smart phone with BLE connectivity.

It operates the sensor using NeuLog application and robotics modules using RobocklySense application. These applications can be found in 'Apple store' or 'Google play'.

The Bluetooth module is also a rechargeable battery module that can be recharged by connecting it to the PC's USB socket or to power adapter using the included USB cable.

The Bluetooth module is also a USB module for connecting the NeuLog sensors to a PC or MAC computers.

The Bluetooth module has 2 LEDs. The first LED (the BAT LED) is a 3 colors LED that indicates the battery status:

- Red when charging the battery.
- Green when the charging is completed.
- Orange when current is consumed from the battery.

The second LED (the BT LED) is a 2 colors LED that indicates the Bluetooth status:

- Blinking blue and red when the Bluetooth is on and not connect to a device.
- Blue when the Bluetooth is paired with a tablet, an iPad or smart phone.
- Red for running a robotics program and also for indicating shutting down the module.

## 7.4 RF Communication module

The RF Communication module allows remote operation of a single sensor or a chain of sensors. The remote single sensor or chain is connected to an RF Communication module and to a Battery Module which powers them all. Another RF Communication module should be connected directly to the Monitor Display Unit, or to the PC via the USB Bridge module. More than two units can be used to cater for more chains of sensors or more independent sensors.

The PC does not need to have either Bluetooth™ or Wi-Fi™ incorporated. Everything required is built into the RF Communication Module.

### **Specifications:**

- Frequency: 433MHz DSSS (Direct-sequence spread spectrum).
- Bit Rate: 1Mbps.
- Maximum distance of use: 9-12 meters even in a none-open space.

## 7.5 Digital display module

The digital display module is a small display module that can be connected to any chain of logger sensors working off-line with a Battery Module.

The digital display module automatically searches for the connected sensors and displays one of them digitally. Scrolling for displaying the reading of another sensor is done by pressing the pushbutton switch on the module.



## 7.6 Graphic display module

The Graphic Display Unit (GDU) is used to run experiments without a PC. The GDU displays the sensor's measurements in digital and graphical forms. It can also be used to program the sensor's experiment setup as well as viewing the input from up to five sensors at a time.

This unit has a user-friendly design with a color graphic display and touch screen.

The Graphic Display Unit is used when a PC is not available for each group. It can work with up to 5 sensors in parallel.

Some of the unit's features are:

- Automatic recognition of sensors.
- Uses preset experiment parameters for easy initiation.
- Communicates with all the sensors or one at a time.
- Controls each sensor's range and measurement units.
- Internal charging circuit is incorporated.
- Mode to view sensor values in real time – up to five at a time.
- Automatic Power-Off for longer battery life.

Sensors are connected to the GDU via its USB (A) socket. Remote connection is also possible by plugging an RF Communication module into it and another into the sensor or sensor chain. This enables both setting up and analyzing the collected data.

The GDU can be connected to a chain of sensors ending with the battery module connected to the last sensor of the chain.

When the GDU is connected to power, it starts scanning and identifies the connected sensors. The located sensors are displayed on the left side of the screen.

The viewer uses the following icons:



- Search for connected sensors.



- Run experiment while displaying the results. The data is also saved in the modules' internal memory and can be uploaded to the viewer at any time.



- Stop experiment run.



- Upload experiment data from the sensors. This function acts also as zoom out.



- Zoom fit.



- Erase screen.



- Experiment setup.



- Tools: Set sensor ID, set RF ID, set screen shut down, turn the viewer off. The last two functions are aimed for saving battery.

## 7.7 Voltage logger sensor

Voltages can be measured across various resistive, capacitive and inductive components, as well as those of photovoltaic cells, batteries and power supplies. This sensor can also be used to measure electrode potentials in Redox reactions and to investigate the charging and discharging of capacitors.

When used in conjunction with the Current sensor the dependence of the current flowing on the applied voltage can be studied in various electric circuits.

This sensor can be used to measure low voltage AC and DC circuits. With its 4mm plugs it can easily be connected into electric circuits.

It can also measure, **using a step-down transformer**, the AC voltage of the Main supply and check its frequency 50/60 Hz (**the input is limited to 60Hz and  $\pm 20V$  maximum**).

**Experiment Duration:** 50 milliseconds to 31 days.

### **Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
$\pm 20$ V	12 bit	1%	0.01 V	100,000

## 7.8 Current logger sensor

This sensor can be used to measure the current in parallel or series low voltage AC and DC circuits.

With its 4mm plugs it can easily be connected into electric circuits.

**Experiment Duration:** 50 milliseconds to 31 days.

### **Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
$\pm 2500$ mA	13 bit	1%	10 mA	100,000

## 7.9 Temperature logger sensor

This is one of the most versatile sensors. It can be used in Biology to monitor ecological systems, to study photosynthesis or to study the effect of temperature on enzymes; in Chemistry, to study exothermic or endothermic reactions, and in Physics to study heat/energy transfer.

**Ranges:** Celsius, Fahrenheit

**Experiment Duration:** 1 second to 31 days.

The sensitive element is within a 180 mm long, 3.2 mm diameter stainless steel tube. This sensor can be used for temperature measurements in solids, liquids or gases.

### Specifications:

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
–40 °C to 140 °C	12 bit	±1 °C	0.1 °C	100
–40 °F to 284 °F		±2 °F	0.1 °F	

## 7.10 Light logger sensor

This sensor is very versatile with applications in many areas of the natural sciences. In Biology it can be used to study photosynthesis. In Chemistry, to study light-emitting chemical reactions. In Physics it can be used to study the effect of changing voltage on a light-bulb's output.

With three ranges, it can be used in low light environments such as a classroom, or high light environments as in daylight outdoors. It measures Illumination.

With both fast and slow modes, it can be used to measure fast light changes such as those produced by light bulbs connected to an AC supply, as well as the near steady levels outside on a sunny day.

**Ranges:** 1,000 lx, 6,000 lx, 150,000 lx

**Experiment Duration:** 50 milliseconds to 31 days.

The light sensor is located in a plastic box just behind an access hole.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
Illumination: 0 to 1,000 lx	12 bit	1 lx	3000
Illumination: 0 to 6,000 lx		6 lx	
Illumination: 0 to 150,000 lx		150 lx	

## 7.11 Oxygen logger sensor

This sensor can be used to make measurements of the level of free-oxygen in air or dissolved oxygen in water.

The free-oxygen in air mode is used to measure changes in oxygen levels during combustion or in reactions that produce oxygen (hydrogen peroxide decomposition). The dissolved-oxygen mode is useful in the study of photosynthesis.

To change mode, click on the Sensor Module box in NeuLog™ software or use the change range option on the Monitor Display Unit.

**Ranges:** % in air, % in liquid, mg/L

**Experiment Duration:** 1 second to 31 days.

The oxygen sensor is designed for use both in the school laboratory and in the field. It employs easy-to-use polarographic (Clark) technology and replaceable membranes are available for it. The electrode itself is constructed of Delrin® for durability.

With its integral thermistor, it provides dependable temperature-compensated measurements. The thermistor is housed in stainless steel and sealed on the electrode's outer wall providing fast, accurate readings.

The installation and replacement of the membrane is quick and easy. Simply fill the membrane cap assembly with DO electrolyte and screw it into place. Two membrane cap assemblies are included with each sensor. Store in de-ionized water between measurements and overnight. Long-term storage, disassemble, rinse in de-ionized water and store dry.

### Sensor reset:

Offset of the probe is simply achieved in open air, taking this as a standard level of 20.9%<sup>1</sup>. First connect the sensor to a voltage source (the USB module plugged into a PC, NeuLog's Monitor Display Unit or Battery Unit) and wait for stabilization of the readings (about 2 minutes). Press the push-button on the sensor's box for about 3 seconds when the readings are stable. The sensor will then be calibrated at 20.9%.

Alternatively, the sensor can be connected to a PC running the Logger Sensors software via the USB module. First click on the Oxygen sensor's Module box to open its Module setup window. Click on the **Extra commands** button and then click on the **Reset** button.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 25 % (in air)	12 bit	0.1%	100
0 to 125 % (dissolved)		0.1%	
0 to 12.5 mg/L (dissolved)		0.01 mg/L	

### Specifications for the electrode are as follows:

<b>Body diameter:</b>	12 mm
<b>Overall length:</b>	150 mm
<b>Cap:</b>	16 mm OD ±30 mm Long
<b>Construction:</b>	Polarographic (Clark Type) design with Silver Anode/Gold Cathode, Delrin body and PTFE membrane
<b>Range/Output:</b>	<ul style="list-style-type: none"> <li>▪ 0-20 ppm Dissolved Oxygen (0-200% saturation)</li> <li>▪ Output: 0-40 mA / 0-400 mA</li> </ul>
<b>Response time:</b>	98% of full response in 60 seconds at 25 °C

<sup>1</sup> This is an assumed stable level in the Earth's atmosphere at sea-level.

## 7.12 pH logger sensor

This sensor can be used to measure the static pH values of common liquids (water, milk, soft drinks, vinegar, etc.) as well as the changing values in titrations or experiments such as those looking at the effect of antacids.

**Experiment Duration:** 1 second to 31 days.

The pH sensor is designed for long life in a variety of general-purpose situations. Its sealed reference system and gel fill make it easy to use and maintain. With an epoxy body it is a durable electrode for use both in the laboratory and in the field.

### Sensor reset:

This sensor gives a fast response across the full pH range and can be calibrated with any standard buffer solution.

Connect the sensor to a voltage source (the USB Bridge plugged into a PC, NeuLog's™ Monitor Display Unit or Battery Unit). Insert the sensor into a pH = 7 buffer and press the sensor's push button for about 3 seconds. The reading is set to 7.

Alternatively, the sensor can be connected to a PC running the Logger Sensors software via the USB module. First click on the pH sensor's Module box to open its Module setup window. Click on the **Extra commands** button and then click on the **Reset** button.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 14	12 bit	0.01 pH	100

### Specifications for the electrode are as follows:

<b>Body diameter:</b>	12mm
<b>Overall length:</b>	150mm
<b>Cap:</b>	16mm OD ±30mm Long
<b>Construction:</b>	Epoxy Body, Round Bulb ASG VIII pH Glass, Sealed gel-filled single-junction reference with fiber frit, Ag/AgCl wire, ATC
<b>Range/Output:</b>	0-14 pH
<b>Response time:</b>	98% of full response in 30 seconds at 25 °C

## 7.13 Relative humidity logger sensor

Measuring Relative Humidity, this sensor can find use in recording variations with weather conditions and the biological effect on such organisms as seedlings and insects.

**Experiment Duration:** 1 second to 31 days.

It is located in a plastic box with exposure of the sensor being through a hole in the side.

### Specifications:

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
0 to 100% RH	16 bit digital	±5% RH	0.1%	100

## 7.14 Heart rate & pulse logger sensor

This sensor can be used to monitor and compare pulse rates under various exercise and rest conditions and to compare the "normal" and "after exercise" pulse rates. Additionally, it can show how blood volume/flow rates in the finger or ear lobe vary with time.

**Ranges:** BPM (Beats Per Minute), Wave

**Experiment Duration:** 1 second to 31 days.

To operate, connect the clip to a finger or ear lobe and start measuring either connected via the USB Bridge to a PC, or to the Monitor Display Unit.

On the PC you can choose to see the pulse wave showing changes of blood volume/flow in the finger or earlobe with time (and calculate the pulse) or get the value of the pulse rate directly via the software.

The operating mode is changed by clicking on the Sensor Module box to display the Heart and Pulse sensor module setup window, and selecting the mode as required.

For best results, the sensor should be kept away from direct sunlight and high intensity lights.



### Specifications:

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
0 to 240 BPM	10 bit		2	100
0-1024 Analog Values		1	1	100

### Specifications for the electrode are as follows:

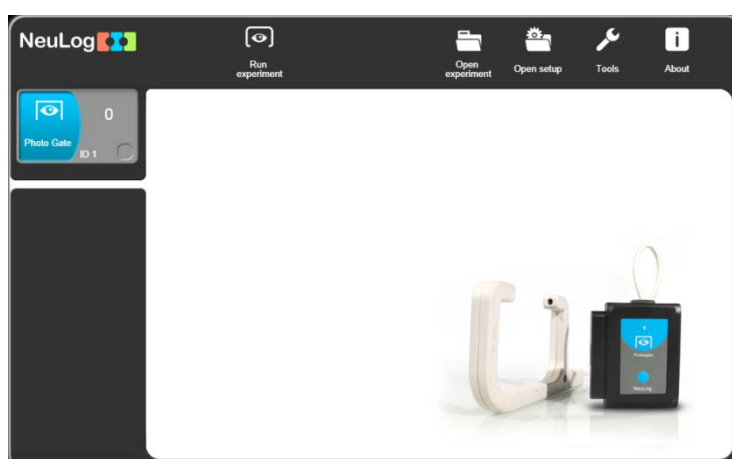
They are both plethysmograph-based and so record changes in blood volume/flow. The sensors consist of an infrared LED transmitter and a matched infrared phototransistor receiver.

## 7.15 Photo gate logger sensor

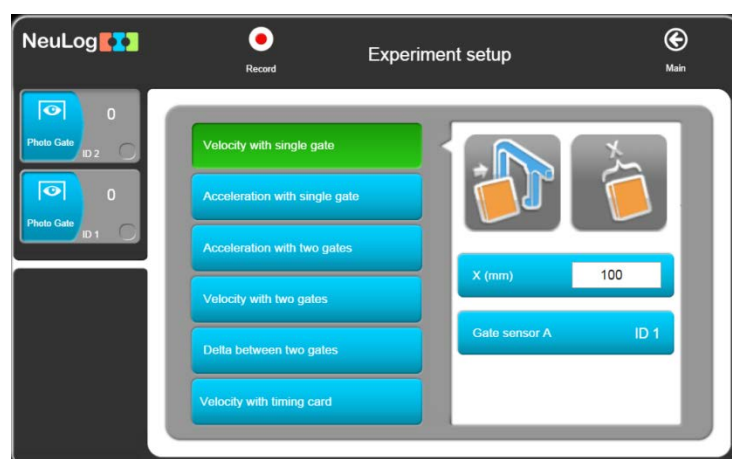
This sensor can be used to study various kinds of motion. With six modes of operation, time, velocity or acceleration can be measured with one or two photo gates and associated timing cards, as well as showing pictorially the status (digital 1 or 0) of the voltage output of the photo gate as timing cards pass through it.

The modes of operation are selected by clicking on the relevant picture.

The photo gate sensor will work only On-Line and, in a manner, different from all the other sensors. When this sensor is connected, the system will relate only to other photo sensors that are connected and disregards all other sensors.



The photo gate sensor has six operating modes that are described in the following screen:

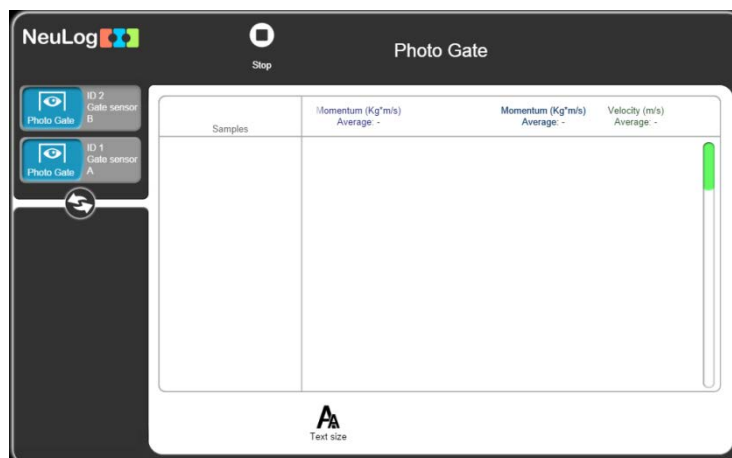


Upon selecting one of the modes of operation, one of the following windows that relate to the specific operating mode will be displayed.





After entering the parameters and press the "Run Experiment" button, every movement of a body that is detected by one or two sensors (according to the operating mode) will display the measured data in a table. There is no graphic display for these modes of operation.



The photo gate is contained in a strong plastic frame with an infrared light emitting diode (LED) on one side and an infrared-sensitive phototransistor on the other side.

#### **Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
Single timing card with one photo gate	16 bit digital	100 $\mu$ S	100 $\mu$ S	10,000
Double timing card with one photo gate				
Single timing card with two photo gates				
Digital status one photo gate				

## **7.16 Pressure logger sensor**

This sensor can be used to monitor chemical reactions that involve gases and to investigate both Boyle's Law and the Pressure Law for ideal gases. It can also prove useful in studies of weather phenomena.

**Ranges:** kPa, Psi, Bar, Atm

**Experiment Duration:** 1 second to 31 days.

The pressure sensor is located in a plastic box. The sensing part is connected to a small tube for connection to pressure sources such as a syringe via an adapter.

#### **Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
0 to 7 atm	13 bit	$\pm 1\%$ 20-30°C	0.01 Atm	100
0 to 100 PSI.			0.1 PSI.	
0 to 700 kPa			0.1 kPa	
0 to 7 B			0.01 Bar	

## 7.17 Force logger sensor

This sensor can measure the mass to weight relationship and study how different pulley systems affect the effort needed to lift weights. It can also be used to measure push/pull forces and impacts.

**Ranges:** 10N, 50N

**Experiment Duration:** 50 ms to 31 days.

The force sensor is contained in a metal box. There is a hook at the bottom of the box that can be connected to various pulling loads. A simple bumper (for push/impact measurements) could be made and attached using a bolt which is placed through a length of plastic tubing.

The sensor can be hung from a universal laboratory stand via a rod through the hole in its box.

This sensor can be operated either facing upwards, downwards and any intermediate (including horizontal) position.

### **Sensor reset:**

Connect the sensor to a voltage source (USB module, Monitor Display Unit or Battery Unit). To reset the reading, just press the sensor's push-button for about 3 seconds.

Alternatively, the sensor can be connected to a PC running the Logger Sensors software via the USB module. First click on the Force sensor's Module box to open its Module setup window. Click on the **Extra commands** button and then click on the **Reset** button.

### **Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
±10 N	14 bit	0.01 N	3000
±50 N			

## 7.18 Sound logger sensor

This sensor has two modes of operation. In slow mode it can be used to measure Sound-pressure level in decibels. In fast mode it can be used to compare different sources of sound, and their waveforms can also be displayed. The frequencies of tuning forks and wind-chimes could be determined and simple electronic signal generators calibrated using it. With two sound sensors the velocity of propagation of sound in various media could be determined by timing a pulse traveling between them.

**Ranges:** dB, Wave

**Experiment Duration:** 25 milliseconds to 31 days.

The sound sensor is located in a plastic box accessible to the atmosphere via a hole in its side.

### Specifications:

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
Level: 40 to 110 dB	12 bit	$\pm 2$ dB	0.1 dB	100
Signal: 0 to 1024		1	1	100,000

## 7.19 Motion logger sensor

This sensor uses an ultrasonic transducer to transmit an ultrasonic wave and measure the time of the echo return. In this way, the sensor measures the distance to an article located against it.

Using the module software, it is able to calculate also the item velocity and acceleration.

The sensor has three modes of operation.

**Ranges:** m, m/s, m/s<sup>2</sup>

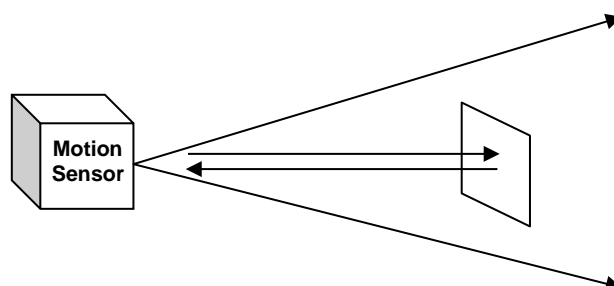
**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
Distance: 0.25 to 10 m	13 bit	1 mm	100
Velocity: $\pm 10$ m/s		0.02 m/s	
Acceleration: $\pm 100$ m/s <sup>2</sup>		0.08 m/s <sup>2</sup>	

### Notes:

- ★ The measurement is based on ultrasonic waves, a sound wave human beings cannot hear. The wave is not narrow. Echo can be received from bodies near the line between the motion sensor and the measured article.
- ★ The size of the measured article must be at least 10 x 10 cm.



## 7.20 Magnetic logger sensor

This is a very sensitive magnetic fields sensor. It can measure a very low level of magnetic fields such as the magnetic field of Earth.

The logger sensor has only one range and measures the magnetic fields in milliTesla (mT).

**Experiment Duration:** 25 milliseconds to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
±10 mT	15 bit	0.001 mT	3000

## 7.21 Conductivity logger sensor

This logger sensor is based on a probe with two flat electrodes with known surface area and distance between them. A signal is supplied to the electrodes and by testing the signal behavior, the conductivity of the solution is calculated.

The logger sensor has three ranges for displaying the solution conductivity:

**Ranges:**     $\mu\text{S/cm}$  – micro Siemens per centimeter  
                    $\text{mg/L}$  – milli gram per Liter  
                   ppm – part per million

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 20,000 $\mu\text{S/cm}$	15 bit	0 to 2000 $\mu\text{S/cm}$ – 0.1 $\mu\text{S/cm}$ Over 2000 – 1 $\mu\text{S/cm}$	100
0 to 18,000 $\text{mg/L}$		0 to 1000 $\text{mg/L}$ – 0.1 $\text{mg/L}$ Over 1000 – 1 $\text{mg/L}$	
0 to 18,000 ppm		0 to 1000 ppm – 0.1 ppm Over 1000 – 1 ppm	

## 7.22 Spirometer logger sensor

The spirometer enables measuring the volume of our lungs. The sensor includes a tube and it measures the air flow that passes through it. The volume (in liters) is calculated by the software calculation function.

The tube has a narrow part in its center and it measures the flow rate by measuring the pressure difference between the two ports of the tube.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
$\pm 10$ L/s	14 bit	0.2 L/s	100

### Notes:

- ★ Disposable laminated papers are included with the sensor.
- ★ A paper must be rolled and put in the tube before using it and exhaling through it.

## 7.23 GSR logger sensor

The Galvanic Skin Response (GSR) logger sensor measures the conductivity of our skin, especially between our hand fingers.

The conductivity of our skin changes according to unconscious emotion effects such as sudden noise, smell, touch, pain or view.

This sensor has two ranges: conductivity in micro-Siemens and arbitrary numbers.

**Ranges:** Signal,  $\mu$ S

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 65279 Arbitrary units	16 bit	1	100
0 to 10 $\mu$ S		10 nS	

### Notes:

- ★ The skin response time from the sudden effect is between 0.1 to 0.5 seconds. The level of the response changes dramatically from one person to another.
- ★ The user must put his hand on a table, chair or on his lap and be still.

## 7.24 Electrocardiogram logger sensor

In a very simple way, this sensor enables to measure the electrocardiogram. It uses permanent electrodes.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 4092 Arbitrary units	12 bit	1	100

## 7.25 Colorimeter logger sensor

The colorimeter measures the levels of color components (red, green, orange and blue) of a solution.

Another option is to measure the solution absorbance of each color component.

The colorimeter logger sensor has an opening for a special square solution tube (a cuvette). The colorimeter turns on 4 different lights (Red, Green, Blue & Orange) in known values and measures the received light that passes through the solution.

This sensor has two modes of operation.

**Ranges:** Red, Green, Blue, Orange, % Transparency, Absorbance

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
Red, Green, Blue and Orange	14 bit	0.01 %	100
0 to 4 absorbance		0.01 abs	

### Note:

The colorimeter comes with three cuvettes.

## 7.26 Barometer logger sensor

This sensor measures atmospheric barometric pressure using a barometer pressure sensor in it.

This sensor has five common ranges for displaying atmospheric pressure:

- KPa – Kilo Pascal
- Atm – Atmospheres
- In Hg – Inches of Mercury
- m – Altitude
- mm Hg – Millimeters of Mercury

The highest barometric pressure is on the sea level – when we go up, the pressure goes down.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
80 to 106 KPa	15 bit	0.1 KPa	100
0.8 to 1.00 Atm		0.01 Atm	
23.62 to 31.30 in Hg		0.01 in Hg	
–382 to 1950 m		0.1 m	
600 to 795 mm Hg		0.7 mm Hg	

## 7.27 Blood pressure logger sensor

The sensor measures the pressure in the air pillow wrapped on the tested person's arm.

Heartbeats affect the blood pressure. That is the reason for the difference between the systolic and diastolic pressure of the tested person.

- Ranges:**
- mm Hg – The average pressure in the air pillow in mm Hg
  - Arb – The pressure beats with no units
  - Arb+mm Hg – The sum of the two above signals.

The two parameters of the blood pressure are the average pressure where the pressure beats are 10% of their maximum value.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 250 mm Hg	13 bit	0.24 mm Hg	100
0 to 820 Arb		0.1 mm Hg	
0 to 250 mm Hg + Arb		0.24 mm Hg	

## 7.28 Drop Counter logger sensor

This sensor is perfect for titrations. Combined with the pH sensor it gives a very nice titration curve.

**Ranges:** Counts, mL

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 6,500 drops	12 bit	1 Drop	100
0 to 6,500 X drop vol. in ml			

## 7.29 Flow logger sensor

This sensor measures water flow. It includes a rotation wheel that rotates when water flows through it. The sensor has inlet and outlet pipes.

The wheel is floating on a bearing and is not connected mechanically to anything else. Its speed is measured by magnetic field changes.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 4.7 m/s	16 bit	0.0001 m/s	100

## 7.30 Force plate logger sensor

This sensor measures heavy weight or forces. We can stand or jump on it.

Handles can be connected to its plates for measuring pulling forces.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
-800 to +2000 N	12 bit	1 N	100



## 7.31 Rotary motion logger sensor

This sensor measures angles, rotation speed or rotation acceleration.

The sensor has a pulley connected to its shaft and the pulley rotation is measured.

**This sensor has four modes of operation:**

Angle, Rad/s, Rad/s<sup>2</sup>, Rev/s

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0° to 360°	16 bit	0.08°	100
±345 Rad/s		0.6 Rad/s	
±32,222 Rad/s <sup>2</sup>		11 Rad/s <sup>2</sup>	
±55 Rev/s		0.02 Rev/s	

**Note:**

To zero the measured angle, click on the **Reset** Button.

## 7.32 Acceleration logger sensor

This logger sensor includes a 3D (three dimensions) acceleration sensor, but only one dimension acceleration can be displayed at a time.

**Ranges:** X-axis, Y-axis, Z-axis

**Experiment Duration:** 50 milliseconds to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
X axis ±80 m/s <sup>2</sup>	12 bit	0.15 m/s <sup>2</sup>	3,000
Y axis ±80 m/s <sup>2</sup>			
Z axis ±80 m/s <sup>2</sup>			

**Notes:**

- ★ The logger sensor measures all the three accelerations at the same time and stores it.
- ★ We can run an experiment on-line, upload one-dimension acceleration, freeze it and upload another, using the off-line method.

## 7.33 Salinity logger sensor

This sensor enables measurements of the salt content in a solution.

**Ranges:** %, mg/L, ppm

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0.0000 to 6.4000%	17 bit	0.0002%	100
0 to 64,000 ppm		1 mg/L	
0 to 64,000 mg/L		1 ppm	

## 7.34 Soil moisture logger sensor

This logger sensor is based on measuring the vacuum pressure in a tensiometer.

A tensiometer is a closed tube with a special ceramic part in its end.

The tensiometer is filled with water and put in the soil. If the soil is dry, water goes out by diffusion through the ceramic holes and vacuum pressure is created in the tensiometer.

When we wet the soil, the vacuum in the tensiometer pulls water into the tensiometer and the vacuum decreases.

This is why soil moisture is measured in pressure level.

**Ranges:** cBar, kPa

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
-20 to 50 cbar	15 bit	0.01 cbar	100
-20 to 50 KPa		0.01 KPa	
% moisture 0-100		5%	

## 7.35 UVB logger sensor

There are different wave lengths of ultra violet light.

The UVB wave length range is 280-320 nm, which is 2% of the total UV radiation.

The UVB radiation affects the vitamin generation in the human body, the immune suppression, skin cancer and cataract.

The intensity of this light is measured in  $\text{mW/m}^2$  (milli Watt per square meter).

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 1,500 $\text{mW/m}^2$	15 bit	0.2 $\text{mW/m}^2$	100

## 7.36 Turbidity logger sensor

This sensor measures the reflected light that enters into a tube containing a solution. As solution turbidity is higher, more light is reflected and measured by the light sensor, located perpendicular to the tube.

The turbidity measurement units are Nephelometric Turbidity Unit (NTU).

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 200 NTU	16 bit	0.20 NTU	100

## 7.37 UVA logger sensor

There are different wave lengths of ultra violet light.

The UVA wave length range is 320-370 nm, which is 98% of the total UV radiation.

The UVA radiation affects the photo aging and photo chemical smog.

The intensity of this light is measured in  $\text{mW/m}^2$  (milli Watt per square meter).

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 65,000 $\text{mW/m}^2$	15 bit	5 $\text{mW/m}^2$	100

## 7.38 Surface temperature logger sensor

This logger sensor is very similar to the temperature sensor NUL-203, without the stainless steel tube.

The sensor can be put on any surface and even in water.

This sensor has two modes of operation.

**Ranges:** Celsius, Fahrenheit

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
-40°C to 120°C	12 bit	0.1°C	100
-40°F to 248°F		0.2°F	

### 7.39 Wide range temperature logger sensor

This sensor is based on a thermocouple sensor that enables measuring very high temperature levels, even the temperature of a flame, as well as very low temperature levels.

**Ranges:** Celsius, Fahrenheit

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
–200°C to 1,200°C	15 bit	0.1°C	100
–328°F to 2,192°F		0.2°F	

### 7.40 Infrared thermometer logger sensor

This sensor measures temperature remotely using an infra-red high accurate sensor.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
–30°C to 382°C	13 bit	0.1°C	100
–22°F to 719°F		0.2°F	

### 7.41 Respiration monitor belt logger sensor

This sensor comes with a belt. It measures the air pressure in the belt which changes according to the breathing of the subject.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 20,000 Arbitrary units	13 bit	1	100

## 7.42 Hand dynamometer logger sensor

This sensor comes with a hand-held unit with a built-in strain gauge. The sensor measures the pressing force on the hand-held unit.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
0 to 500 N	16 bit	0.1 N	100
0 to 112 lb		0.02 lb	
0 to 50 Kg		0.01 Kg	

## 7.43 Calcium logger sensor

The calcium sensor enables measurements of ionic calcium ( $\text{Ca}^{2+}$ ) concentration in aqueous samples. This measurement is very important when evaluating water quality. It can also be used to determine calcium – magnesium by EDTA titration.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
0.02 to 40,000 mg/L	15 bit	0.04 at 0.02 to 100 mg/L 0.4 at 100 to 1,000 mg/L 40 at 1,000 to 40,000 mg/L	100
0.02 to 40,000 ppm		0.04 at 0.02 to 100 ppm 0.4 at 100 to 1,000 ppm 40 at 1,000 to 40,000 ppm	

## 7.44 Chloride logger sensor

The chloride sensor can be used to measure the concentration of chloride ions ( $\text{Cl}^-$ ) in aqueous samples. This measurement can be an indication of the salinity of water samples. The sensor can be used to study samples of drinking water with different degrees of chlorination.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
1.8 to 35,500 mg/L	15 bit	0.4 mg/L at 1.8 to 1,000 mg/L 40 mg/L at 1,000 to 35,500 mg/L	100
1.8 to 35,500 ppm		0.4 ppm at 1.8 to 1,000 ppm 40 ppm at 1,000 to 35,500 ppm	

## 7.45 Ammonium logger sensor

The NeuLog ammonium sensor can be used to measure the concentration of ammonium ions ( $\text{NH}_4^+$ ) in aqueous samples.

It can be used to evaluate the degree of contamination of water due to the use of fertilizers.

Ammonium measurements can also be very relevant to study the nitrogen cycle in general and to relate this cycle to plants and algae.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
0.02 to 18,000 mg/L	15 bit	0.04 at 0.02 to 100 mg/L 0.4 at 100 to 1,000 mg/L 40 at 1,000 to 18,000 mg/L	100
0.02 to 18,000 ppm		0.04 at 0.02 to 100 ppm 0.4 at 100 to 1,000 ppm 40 at 1,000 to 18,000 ppm	

## 7.46 Nitrate logger sensor

The nitrate sensor can be used to measure the concentration of nitrate ions ( $\text{NO}_3^-$ ) in aqueous samples. Nitrates are used in fertilizers and can contaminate water. Also, untreated human sewage can be a source of nitrate contamination. All this can be studied with the nitrate sensor. Nitrate measurements can also be very relevant to study the nitrogen cycle in general and to relate this cycle to plants and algae.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0.1 to 14,000 mg/L	15 bit	0.4 mg/L (0.1 to 1,000 mg/L) 40 mg/L (1,000 to 14,000 mg/L)	100
0.1 to 14,000 ppm as N		0.4 ppm (0.1 to 1,000 ppm) 40 ppm (1,000 to 14,000 ppm)	

## 7.47 Anemometer logger sensor

The anemometer sensor enables measurements of the wind velocity. Combined with temperature, relative humidity, dew point and barometric pressure sensors, it can be used to make very interesting weather measurements.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
0.00 to 120.00 km/hr	15 bit	0.01 km/hr	100
0.00 to 75 mph		0.01 mph	

## 7.48 GPS position logger sensor

The GPS position logger sensor determines its latitude, longitude, altitude and horizontal velocity anywhere on earth through signals received from the Global Positioning System. It can be used by itself or together with other NeuLog sensors to perform outdoor experiments in environmental science, physics and more.

### Specifications:

<b>Position accuracy</b>	10 m, 2D RMS 5 m, 2D RMS with WAAS enabled
<b>Velocity accuracy</b>	0.1 m/s
<b>Maximum sample rate</b>	1 Hz
<b>Time to first fix (average)</b>	42 s, cold start 1 s, hot start
<b>Channels</b>	20

## 7.49 Dew point logger sensor

This sensor measures temperature and humidity in a volume and gives the temperature below which the water vapor in that volume of air (at a constant barometric pressure) condenses into liquid water (the dew point).

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
-114.0 to 109.0°C	12 bit	0.1°C	100
-182.0 to 228.0°F		0.1°F	



## 7.50 Charge logger sensor

This sensor measures electrostatic charges. It can be seen as a highly sensitive electroscope indicating whether a charge is positive or negative. Other uses are: to explore the nature of static charge, to measure both charge and voltage, to measure charge by induction, quantify the charge on a capacitor or discover the charge distribution on a conducting sphere.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
±5.000 nC	15 bit	1 pC	100
±20.00 nC		10 pC	
±100.00 nC		100 pC	
±500.0 mV		0.1 mV	
±2,000 mV		1 mV	
±10,000 mV		1 mV	

## 7.51 Geiger Radiation logger sensor

The NeuLog Geiger sensor can be used for any science experiments or activities which utilize accurate radioactivity readings such as in the fields of: Physics, Chemistry, Biology and Environmental science.

The sensor comes pre-calibrated so you can start experimentation right out of the box using this guide.

The sensor can easily be reset to zero at any time.

Radioactivity is the spontaneous emission of radiation. This emission can occur from unstable atomic nuclei or as a consequence of a nuclear reaction. The most common types of radiation are alpha, beta and gamma. The NeuLog Geiger sensor measures all three types of radiation. The radioactivity of a sample can be measured by counting how many ionizing events occurred in a period of time or as rate (counts per second, for example).

Hundreds of possible experimental subjects that can be done with the NUL-247 sensor are: Radioactivity and distance, Lifetime measurements, Biological radioactive markers, measuring half-lives (amount of time it takes for half of the atoms in a radioactive substance to break down or decay), Radiation shielding, etc.

The Geiger counter sensor uses the following units of measure:

- Counts: Total number of ionizing events.
- Counts/s: Number of ionizing events per second.
- Counts/m: Number of ionizing events per minute.
- $\mu\text{Sv/h}$ : Microsievert per hour.
- $\mu\text{R/h}$ : Micro roentgen per hour.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
0-65,500 Counts	16 bit	1 Count	100
0-8000 Counts/s		1 Counts/s	
0-65,500 Counts/m		1 Counts/m	
0-300 $\mu\text{Sv/h}$		1 $\mu\text{Sv/h}$	
0-30,000 $\mu\text{R/h}$		1 $\mu\text{R/h}$	

## 7.52 mA current logger sensor

The current sensor can be used for any science experiment which utilizes current readings. It is used in the fields of Physics, Electronics, Chemistry, Biology, etc.

The sensor comes pre-calibrated so you can start experimentation right out of the box using this guide.

Hundreds of possible experimental subjects that can be performed with the mA current sensor are: Fuel cells, battery chemistry, electrical parallel circuits, electrical series circuits and electronics.

The current sensor's measurement units are:

**Mili-Amperes (mA):** Amperes are the SI base unit of electric current.

**Experiment Duration:** 50 milliseconds to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max sample rate (S/sec)
$\pm 250$ mA	15 bit	1%	0.1 mA	3000

## 7.53 Resistance logger sensor

The resistance sensor can be used for any science experiment which utilizes resistance readings. It is used in the fields of Physics, Electronics, Chemistry, Biology, etc.

The sensor comes pre-calibrated so you can start experimentation right out of the box using this guide.

Hundreds of possible experimental subjects that can be performed with the Resistance sensor are: Electrical components resistance measurements, electrical parallel circuits, electrical series circuits and electronics.

The resistance sensor's measurement units are:

**Ohm ( $\Omega$ ):** The ratio between the voltage on and the resistance through an electrical component.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
0 to 200 k $\Omega$	15 bit	(0 to 10 k $\Omega$ ) 0.001 k $\Omega$	100
		(10 to 60 k $\Omega$ ) 0.01 k $\Omega$	
		(60 to 200 k $\Omega$ ) 0.1 k $\Omega$	

## 7.54 $\pm 25V$ voltage logger sensor

The voltage sensor can be used for any science experiment which utilizes voltage readings. It is used in the fields of Physics, Electronics, Chemistry, Biology, etc.

The sensor comes pre-calibrated so you can start experimentation right out of the box using this guide.

Hundreds of possible experimental subjects can be performed with the Voltage Sensor. Examples are: Fuel cells, battery chemistry, electrical parallel circuits, electrical series circuits and electronics.

The voltage sensor's measurement units are:

**Volts (V):** The SI derived unit for electrical potential difference across two determined points.

**Experiment Duration:** 50 milliseconds to 31 days.

### Specifications:

Range and operation modes	Max input	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
$\pm 25$ V	30 V	15 bit	1%	0.01 V	100,000

## 7.55 ORP logger sensor

The ORP (Oxidation Reduction Potential) sensor can be used to quantify whether a substance is a strong oxidizing agent or a strong reducing agent. For example, the ORP electrodes are used to measure the oxidizing ability of chlorine in swimming pools.

The electrode has two components: a measuring half-cell comprised of platinum metal immersed in the solution in which the redox reaction is taking place, and a reference half-cell (sealed gel-filled Ag/AgCl) to which the platinum half-cell is referenced.

Possible experiments that can be performed with the ORP sensor are: Redox titration, Water treatment and quality monitoring, Ozone treatment, Bleach production, Fruit and vegetable washing, Pulp bleaching, Chlorine addition for swimming pools and spas, oxidation in aquariums etc.

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)	Temp. range
-1500 mV to 1500 mV	16 bit	-1000 to 1000: 0.1 mV Over 1000: 1 mV Below -1000: 1 mV	100	0-60°C

## 7.56 CO<sub>2</sub> logger sensor

This logger sensor is based on an electromechanical reaction between CO<sub>2</sub> gas and the sensor.

The result of the electromechanical reaction is voltage, measured by the logger sensor.

The measure units are ppm (parts of CO<sub>2</sub> per million of air).

**Experiment Duration:** 1 second to 31 days.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
350 to 50,000 ppm	14 bit	1 ppm	100

### Note:

Prior to each use, the CO<sub>2</sub> sensor needs to warm up for roughly 2 minutes.















### Open air mode:

Although the CO<sub>2</sub> sensor does not need to be calibrated, it is recommended to offset its probe.



















The sensor offsets to the standard atmospheric CO<sub>2</sub> concentration of 380 ppm in open air (assuming stable levels in the Earth's atmosphere at sea level).





















# Appendix A – Modules





















## A.1 Accessory modules

Module	Module Symbol	Photographic Image	Purpose
USB Bridge Module			Connects logger sensors to PC
Battery Module			Powers logger sensors when not connected to PC or Monitor Display Unit
Built-in Bluetooth Module with Battery			Functions as a USB module, Battery module and Bluetooth
RF Communication Module			Enables wireless connection of logger sensors to PC and Monitor Display Unit
Viewer display module			Enables data collection when access to computers or other smart devices is difficult or not at all possible
Viewer Graphic Color Display Module			Enables data collection when access to computers or other smart devices is difficult or not at all possible
Wi-Fi Communication Module			Enables data collection and analysis through any wireless device





















## A.2 Logger sensors modules























Module	Module Symbol	Photographic Image	Purpose
Voltage logger sensor			Measures voltage in DC and AC circuits
Current logger sensor			Measures current in DC and AC circuits
Temperature logger sensor			Measures temperature
Light logger sensor			Measures level of Illumination
Oxygen logger sensor			Measures % oxygen in air and dissolved in water
pH logger sensor			Measures relative pH
Relative Humidity logger sensor			Measures humidity
Heart Rate & Pulse logger sensor			Measures pulse rate and blood flow
Photo/Light gate logger sensor			Measures time and, indirectly, speed/velocity and acceleration

Module	Module Symbol	Photographic Image	Purpose
Pressure logger sensor			Measures gas or air pressure
Force logger sensor			Measures forces, both push and pull
Sound logger sensor			Measures sound level and displays waveforms
Motion logger sensor			Measures distance, velocity and acceleration
Magnetic logger sensor			Measures magnetic field intensity
Conductivity logger sensor			Measures solution conductivity
Spirometer logger sensor			Measures lung air flow and volume
GSR logger sensor			Measures Galvanic Skin Response
Electrocardiogram logger sensor			Measures electrocardiogram
Colorimeter logger sensor			Measures solution RGB color transfer and absorbance

Module	Module Symbol	Photographic Image	Purpose
Barometer logger sensor			Measures air pressure and altitude
Blood pressure logger sensor			Measures blood pressure
Drop Counter logger sensor			Counts falling drops
Flow logger sensor			Measures water flow
Force plate logger sensor			Measures high weight
Rotary motion logger sensor			Measures rotary speed, acceleration and rounds
Acceleration logger sensor			Measures 3D acceleration
Salinity logger sensor			Measures salt content in a solution
Soil moisture logger sensor			Measures soil moisture
UVB logger sensor			Measures UVB radiation



Module	Module Symbol	Photographic Image	Purpose
Turbidity logger sensor			Measures solution turbidity
UVA logger sensor			Measures UVA radiation
Surface temperature logger sensor			Measures temperature of a surface
Wide range temperature logger sensor			Measures a wide range of temperature levels
Infrared thermometer logger sensor			Measures temperature remotely
Respiration monitor belt logger sensor			Measures the breathing of a subject
Hand dynamometer logger sensor			Measures the pressing force
Calcium logger sensor			Measures the concentration of ionic calcium (Ca <sup>2+</sup> )
Chloride logger sensor			Measures the concentration of chloride ions (Cl <sup>-</sup> )
Ammonium logger sensor			Measures the concentration of ammonium ions (NH <sub>4</sub> <sup>+</sup> )

Module	Module Symbol	Photographic Image	Purpose
Nitrate logger sensor			Measures the concentration of nitrate ions ( $\text{NO}_3^-$ )
Anemometer logger sensor			Measures the velocity of the wind
GPS position logger sensor			Determines latitude, longitude, altitude and horizontal velocity anywhere on Earth
Dew point logger sensor			Gives the temperature below which water vapor condenses into liquid water
Charge logger sensor			Measures electrostatic charges
Geiger Counter logger sensor			Measures alpha, beta and gamma radiation
250 mA Current logger sensor			Measure current in the mA range
Resistance logger sensor			Measures the current through the resistance and the voltage on it
$\pm 25$ V Voltage logger sensor			Measures voltages across various resistive, capacitive and inductive components
ORP logger sensor			Quantify whether a substance is a strong oxidizing agent or a strong reducing agent
$\text{CO}_2$ logger sensor			Measures $\text{CO}_2$ in air

Comprehensive details of each of these modules are provided in chapter 7.

## Appendix B – Through Wi-Fi

The Wi-Fi module is without a doubt one of the most advanced and innovative elements that we have to offer. Data collection and analysis with NeuLog sensors can be performed through any device with wireless capabilities such as iPads, Android tablets, smartphones, Windows, Mac, and Linux based computers. The Wi-Fi module can seamlessly transform group projects by connecting up to 5 devices onto the wireless network at a single time – promoting interaction and allowing members to have their own dataset.

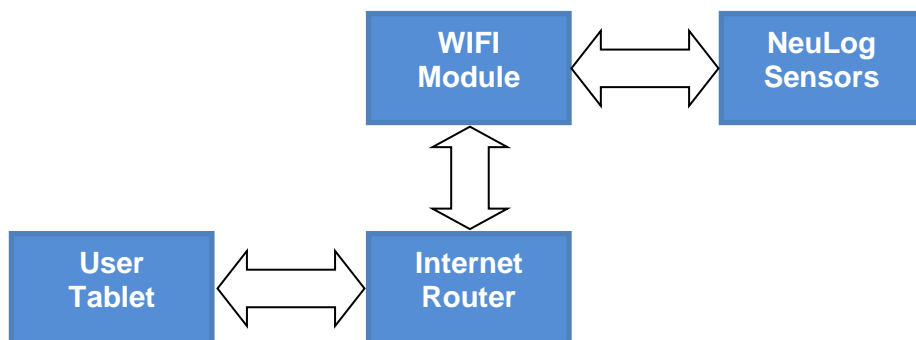
There is no need to download and install any application or software as they are built directly into the Wi-Fi module which transmits its own closed wireless network. This means that there is no need for a wireless network – though if there is one, a simple setting can be changed on the Wi-Fi module to allow surfing of the web at the same time!

The Wi-Fi module has three operating modes:

1. **Access Point (AP)** when there is no wireless Internet communication.



2. **Client Mode** in places with wireless Internet communication. The Tablet communicates with the Wi-Fi module as if it is a remote Internet website. In this manner, the user can browse in parallel to use the system with access to other sites on the web.



3. As a USB module connected directly to a PC or MAC.



## B.1 Using the Wi-Fi module

The Wi-Fi module is a very advanced piece of equipment; it has the capability to transmit its own wireless network as well as record data from up to 5 sensors at a time.

The Wi-Fi module can be powered by a battery module or by a USB power source.

It can also be used as USB module when it is connected to a PC or MAC and under local NeuLog software.

Notice that on the front of the Wi-Fi module there are four LED lights labeled AP, CL, TR and USB.

**AP (blue LED):** When the blue LED is the only light on, the Wi-Fi module is in Access Point mode (described below) and is transmitting a closed wireless network which you can connect devices to.

**CL (green LED):** When the green LED is the only light on, the Wi-Fi module is in Client Mode (described below) and allows your wireless devices to control sensors through the website [www.Wifi201.com](http://www.Wifi201.com) as well as browse the internet.

**TR (red LED):** The red LED blinks when there is active communication between any connected sensors and the NeuLog software.

**USB (yellow LED):** The yellow LED remains lit when the Wi-Fi module is working in USB mode (detailed below). USB mode can be turned on and off by pressing the button on the front of the Wi-Fi module three times.

### **Control and view modes:**

When multiple users are connected to the Wi-Fi module's network; one user at a time can enter "control mode" while the others users are defaulted to "view mode".

**Control mode** – Entering control mode allows a user to manipulate the experimental parameters and begin data collection using the software; this prevents multiple users from all trying to change the experiment at the same time.

When one user enters control mode, the "Control Mode" button at the top of the screen becomes blocked to prevent other users from entering control mode as well. The other users will be in "view mode".

To leave control mode, simply click the "View Mode" button at the top of the screen. This will automatically re-enable the "Control Mode" button for all users.

**View mode** – When users first connect to the Wi-Fi module's network, they automatically begin in "view mode", where they have almost full access to the software; only the ability to manipulate data and start/stop experiments is not possible. Users in view mode have the full ability to view data in real time, manipulate the data and graph, save files, etc.

**Important:**

To exit the software properly, enter “view mode” before closing the software and unplugging the Wi-Fi module. In the event that anyone used the Wi-Fi module as the controller and forgot to disconnect from it, the Wi-Fi module will not allow any other user to connect to the Wi-Fi module as controller.

In order to allow another controller to access the Wi-Fi module, press and hold the push button located on the front panel of the Wi-Fi module for 3 seconds until all 3 lights turn on – this will refresh the module resetting it back to having no users in “control mode”.

## **B.2 Access point mode use**

Access point mode is the default operating mode for the Wi-Fi module; it transmits its own closed wireless network which allows up to 5 devices to connect to it at a time. No prior wireless networks are required, making this option both very portable and unique. Since the network is closed, you cannot browse the internet; if you wish to do so while using the Wi-Fi module, please refer to section B.1.

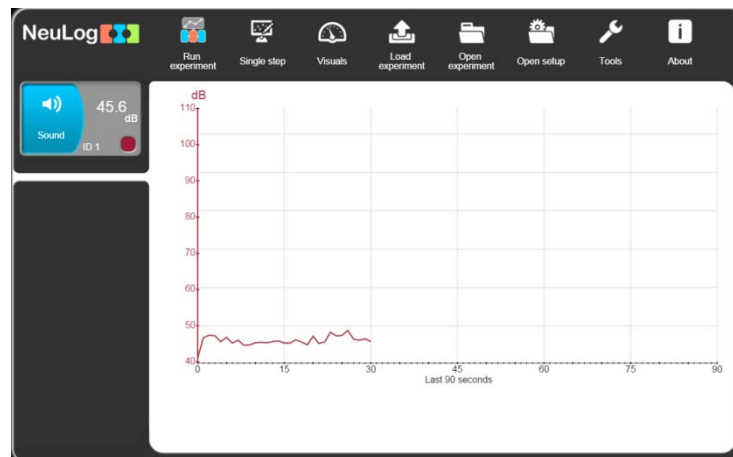
1. Connect up to 5 sensors directly to the left side of the Wi-Fi module (no wires required).
2. Connect the Wi-Fi module to a battery module or to a power supply with a USB to micro USB cable.
3. The Wi-Fi module indicator lights will flash; take no action until the LED to the far left turns blue.
4. Take your tablet or smart phone, go to the Wi-Fi settings and select the NeuLog network which matches the Wi-Fi module ID found on the back of the Wi-Fi module. (**NeuLog1334** for example)
5. Give your tablet or smart phone 1-2 minutes to connect to the Wi-Fi module network.
6. Once the tablet or smart phone is connected go to your browser and type in the website **wifi201.com** into the URL bar, then wait for 30-60 seconds.


**Note:**

There are two modes of operation: "**Control Mode**" and "**View Mode**".

Only one device can be in control mode at a time; the remaining devices must be in “View mode”. Switching between them is both possible and very easy. The control mode allows the user to change experimental parameters and both start and stop data collection. The view mode allows the user to view and analyze the data being recorded.

7. If you are the first to connect to the Wi-Fi module you will get the "Control Mode".



8. Once the sensors are found, you will see an icon on the left side of the screen for any detected sensors. The icon will display data in real time.
9. To set the sensors' settings, click on each sensor's icon.
10. To run an experiment and collect data click on the **Run experiment**  button.

## B.3 Client mode use

If you have a wireless network and wish to browse the internet while using the Wi-Fi module, you can use the client mode to connect the Wi-Fi module to your local internet. By default, the Wi-Fi module starts in "Access point mode" but can easily be changed to "Client mode".

### Note:

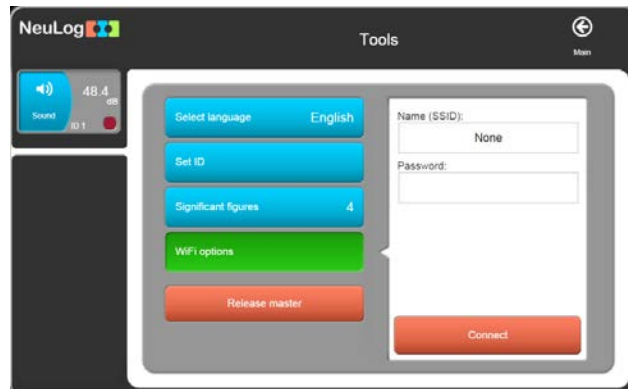
Before following this procedural guide, you must configure your Wi-Fi module using the "Access point mode" guide in section B.2. Access point mode is most commonly used.

1. Configure your Wi-Fi module as per the "Access point mode" guide beginning at section B.2 of this document.

2. Click on the **Tools**  button.



3. Click the **WiFi options** button.



4. Input your local internet connection's name and password in their respective text fields.
5. Click on the **Connect** button. This step attempts to connect the Wi-Fi module directly to your local wireless network allowing you to browse the internet.

### Note:

During this time, the green light on the Wi-Fi module will flash. In the event that the NeuLog site could not be accessed, the blue light will turn back on and the Wi-Fi module will return to access point mode.

6. If the connection to the NeuLog site is successful, you will be disconnected from the NeuLog closed wireless network (i.e. NeuLog1334) and the green light on the Wi-Fi module will remain on.
7. At this point you must connect to your local wireless connection (the information you put in step 4).
8. On the new screen you get, click the **Connect** button to reconnect the browser to the Wi-Fi module
9. You will now be in client mode with the ability to browse the internet using your tablet or smart phone.
10. When connecting additional wireless devices, simply type the address **wifi201.com** into your device's internet browser bar. A prompt will ask for the wifi201 ID; this is the digit code located on the back of the Wi-Fi module.



Access **wifi201** from Anywhere

Enter the wifi201 id as it appears on the product

wifi201 ID:

Numbers only

☐ Add this Unique wifi201 address to my favourites.

**Connect**

11. Click **Connect** and now you will be able to access the NeuLog software broadcast from the Wi-Fi module.

The next time the Wi-Fi module is turned on, it will attempt to enter the client mode by connecting to the same wireless connection. If the connection fails, the Wi-Fi module will restart back in the access point mode.

### **Important:**

To exit properly, enter the **View Mode** before closing the software. In the event that any user used the Wi-Fi module as a controller and forgot to disconnect from it, the Wi-Fi module will not allow any other user to connect to the Wi-Fi module as a controller.

In order to allow another controller to access the Wi-Fi module, press on the pushbutton on the Wi-Fi module panel continuously for about 3 seconds until all 3 lights are lit and then release the pushbutton.



## B.4 Using the Wi-Fi module in USB mode

The USB mode allows you to use your Wi-Fi module as if it were a USB module. This requires a computer with the NeuLog software (available as a free download on [www.neulog.com](http://www.neulog.com)).

By connecting the Wi-Fi module to your sensors and computer via the included USB to micro-USB cable, you can stream data directly from your sensors to the NeuLog software.

To enter the USB Mode:

1. Download and install the NeuLog software on your computer.
2. Connect the Wi-Fi module to the computer with the NeuLog software using the included USB to micro-USB cable; observe the LEDs blink for a moment while the module powers on.
3. Connect your sensors to the side of the Wi-Fi module, the red LED on each sensor should blink to show that they are working properly.
4. Press the button located on the front panel of the Wi-Fi module three times, the yellow LED labeled 'USB' should turn on.
5. Open the NeuLog software.

**Note:**

The software will run through your default browser but requires no internet connection.

6. Your connected sensors will automatically be detected.
7. Once your sensors are detected, you can begin experimenting in USB mode!

**Note:**

To switch back to the Access Point mode from the USB mode, press the button on the Wi-Fi module's front three times again.

## B.5 Troubleshooting walkthrough

Due to the technological complexity of the Wi-Fi module and the ever-updating software and hardware found on today's wireless devices, it is possible that you may run into some performance issues while the unit is communicating with your wireless device. Luckily, for these circumstances the Wi-Fi module can easily be cleared and updated!

If you notice that the performance of your Wi-Fi module is acting sporadic, please follow the guides below:

### **Restarting the Wi-Fi module:**

Restarting the Wi-Fi module will often clear up any connectivity issues you may be having and is an extremely easy process.

1. Connect the Wi-Fi module to a power source – this can be either a charged battery module or directly to your computer using the USB to micro-USB cable.
2. The LED lights on the Wi-Fi module will turn on to indicate that it is now being powered.

### **Note:**

You do NOT need to wait for the network to be transmitted at this point.

3. Once the Wi-Fi module is powered, simply press and hold the button on the front panel of the Wi-Fi module for roughly 4 seconds (until the green, red, and blue LEDs turn on).
4. When the blue LED is the only light on, the closed wireless network is being transmitted and you can connect devices as usual.
5. If the behavior of the Wi-Fi module is still sporadic, please continue to the Updating the Wi-Fi module's firmware walkthrough below.



