NeuLog

Neuron Logger
Sensor Network Technology

User Guide

Scientific Educational Systems

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.

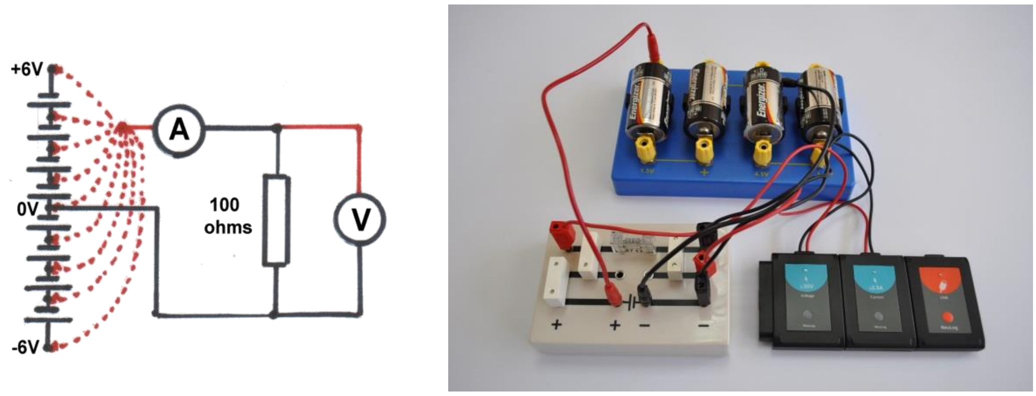


Figure 1-1 Voltage-Current Measurement Experiment

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 WiFi module. Tablets are connected to the sensors through the WiFi 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 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 Unit.

One chain of sensors can be divided into more chains by adding RF communication modules to all the sensors' chains allowing remote connection of up to 30m (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 25ms to 31 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 operated.

1.3 Plug and play system

The philosophy behind logger sensors is a "plug and play" system. Connect the experiment's 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, the 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 different types of measurements that are usually done by more than one sensor.

The built-in software 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.**

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.

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.

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. 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 = 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.

The sensors can remain connected to the MDU at **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, a table or both, 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), $(1000 \cdot A \cdot B)$, $(A \cdot K)$, (e^A), (10^A) 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 sensor 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 sensor.

The NeuLog^{TM} software is very rich and at the same time intuitive. It is very simple to use.

There are two types of NeuLog^{TM} programs. One is a version for PC with Windows and its icon is . The second is for any PC (Windows, MAC, and Linux) and its icon is NeuLog.

This manual describes the NeuLog^{TM} program for browser mode through few sensors.

1.7 Safety instructions

- Read and understand these entire instructions before proceeding.
- Keep these instructions.
- This equipment is **not** designed to perform 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 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 components are revealed for any reason.
- Do not operate module with damaged cord, wires or electrical parts. Use only cords supplied with the module.
- Use only power source approved by SES or enclosed with the training system.
- The USB module is also an approved power source for the NeuLog^{TM} modules.
- Use modules only to measure the parameters for which they are 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 sources such as radiators, heat registers or other apparatus that produce heat.
- Unplug the module during lighting 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 receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Scientific Educational Systems Ltd. is 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.

- Open the setup file on the CD you received with the system.
- 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 installation and USB driver installation. 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 the '**Cancel**' button.

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

2.2 NeuLog sensors with tablet through WiFi

Most of the tablets do not have USB port and this is why we cannot connect the USB module to them.

Instead, we use a WiFi module, called **WiFi-201**. This module comes with the NeuLog software in it. This software can be run under any browser.

This mode of operation has some more advantages. One can operate the system and run the experiments and many others can view his results and screens.

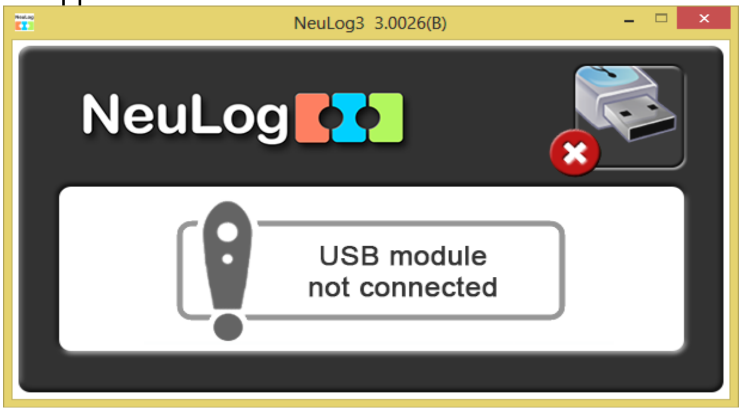
What are the options of this mode of operation and how to run the software until we get the main screen, is described in **appendix B**.

If you are using the **WiFi-201 module**, use the instructions in Appendix B until you get the NeuLog software main screen and continue from section 2.3.

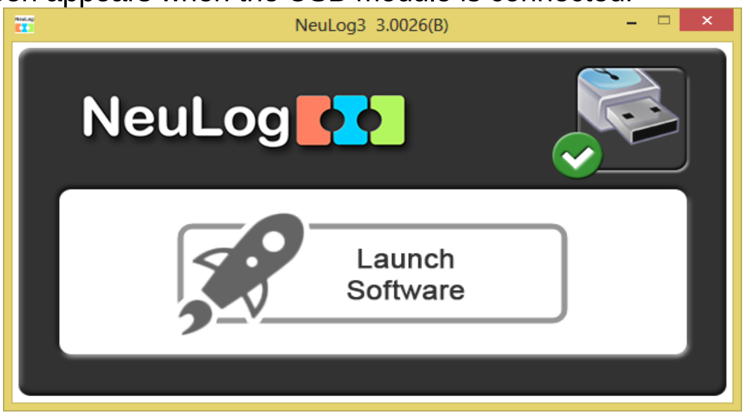
2.3 Logger sensors main screen

- 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:

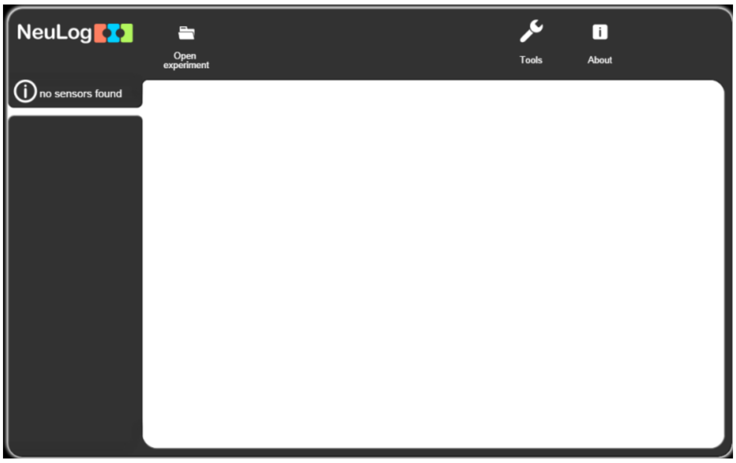


This screen will stay in the background for closing the NeuLog software.

Note:
Closing NeuLog™ program doesn't close the app window. The app should be closed separately.

The NeuLog™ application will automatically open in new app window when the USB module is found.
When the app starts it displays 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, displays the current measured value on them and also displays an accumulated graph of one second rate samples.

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

Searching the connected sensors is done automatically. Changing the sensors connected to the USB module, will change the displayed modules on the screen in few seconds automatically.

The NeuLog™ software is an intuitive program that guides the user how to use through the screen icons. Please, do not be afraid to play with the system. This is the main idea of the NeuLog™ system – use it and have fun.

2.4 Connecting a sensor

- Connect the USB Bridge module  to a USB port on the PC with the USB-mini USB cable.

- Connect the Sound sensor  to the USB Bridge 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:

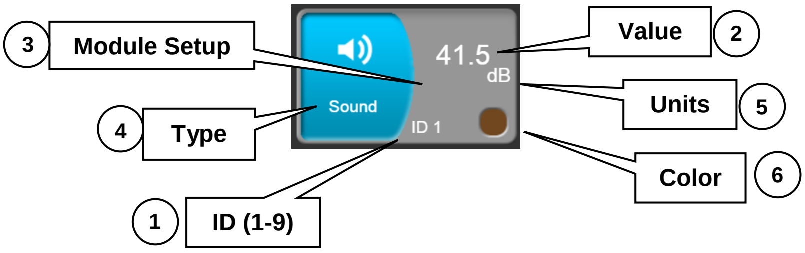
Searching the connected sensors is done automatically. Changing the sensors connected to the USB module, will change the displayed modules on the screen in few seconds automatically.

Any newly detected Sensor Module boxes are displayed vertically in the Module window.

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

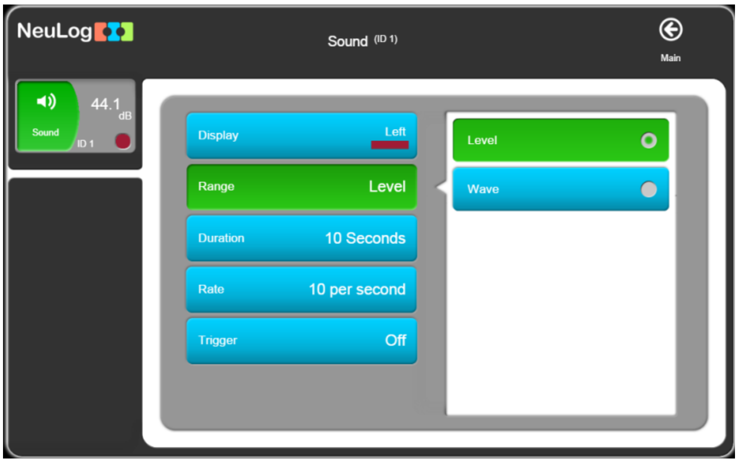
This is the "plug and play" method. Connect the sensors to the PC through the USB module, run the software and the system is ready to use.

2.5 Sensor module box



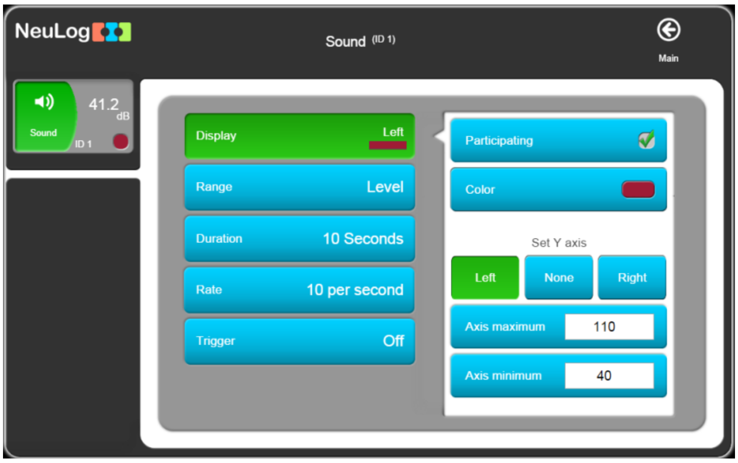
1. **ID** – Displays the sensor's ID. Up to 9 sensors of the same type can be connected in a chain.
2. **Value** – Displays the sensor's numerical value.
3. **Module Setup** – Opens the sensor's setup window.
4. **Type** – Displays the sensor's type (Light, Temperature, etc.).
5. **Units** – Displays appropriate units of measurement (lx for a Light sensor, °F or °C for a temperature sensor, etc.).

- Pressing on the sensor module box opens the parameter window (Module Setup) for that particular sensor.



- The measurement range of the sensor is set by the Range button, pressed as default button.

- The **Display** button enables to determine whether this sensor participate in the experiment or not, what will be the color of its graph, where will be its Y axis and what are the axis limits.



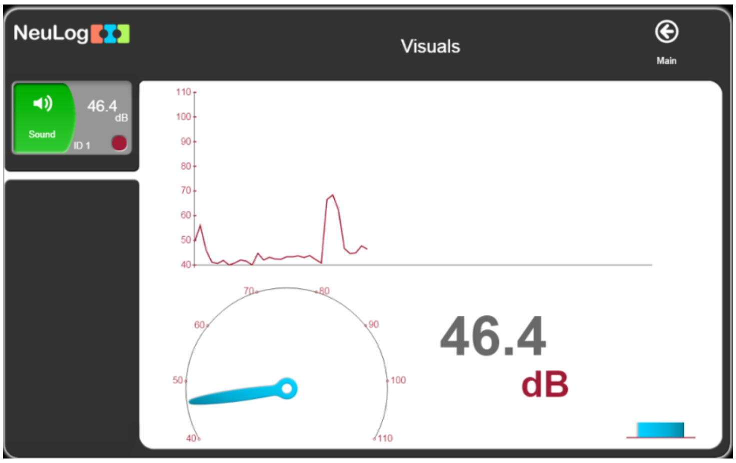
The **Duration**, The **Rate** and the **Trigger** buttons are aimed for experiments where every sensor has its own experiment setup parameters.

- Some sensors have extra commands (such as Reset, calibrate, etc.). This sensors gets **Extra Command** button as in the following Force sensor screen.

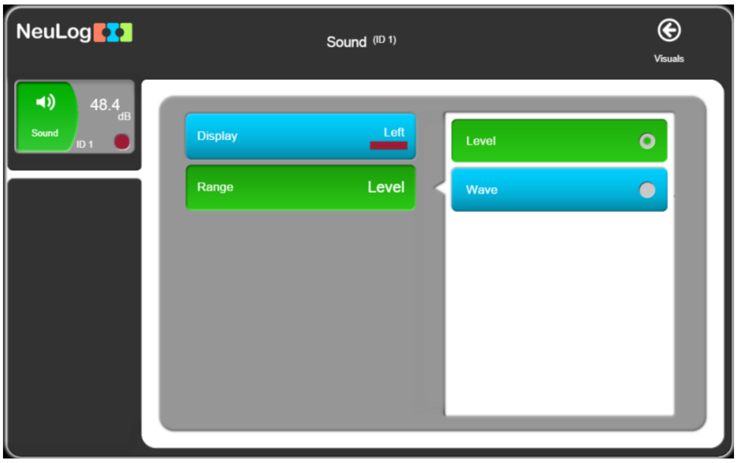
2.6 Visuals mode

- Pressing the Visuals Mode  button will display the Visuals screen, which is divided into four windows that show the samples in various display modes:

  a. Bar graph
  b. Digital measurement display
  c. Analogue meter
  d. Accumulative graph that shows a new sample every second. The graph shows the last minute.



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



- Press Back to return to the main screen.

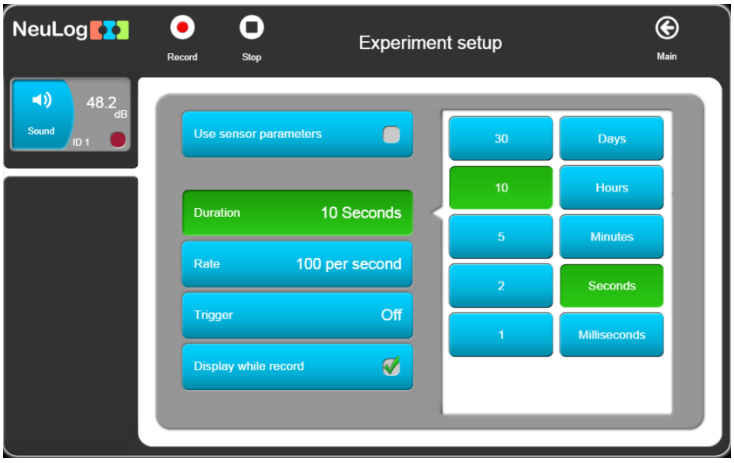
Chapter 3 – On-line Experiment Mode

In this chapter you will run an experiment with the temperature sensor in order to see and use the features of the **On-Line Experiment** mode. In this mode, the experiment is controlled by the PC. Results are recorded and displayed in real-time.

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

3.1 Experiment setup

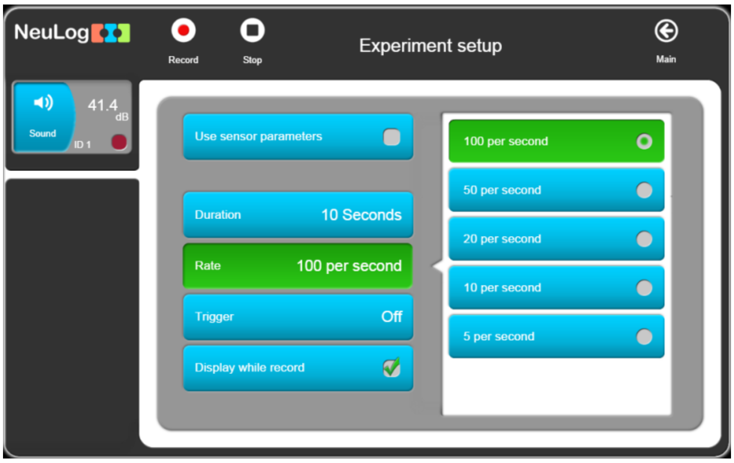
- Click on the **Run experiment icon**  to display the Experiment setup screen below.



- This window enables to define the experiment parameters: **experiment duration**, **sample rate** and **trigger** for all of the sensors.

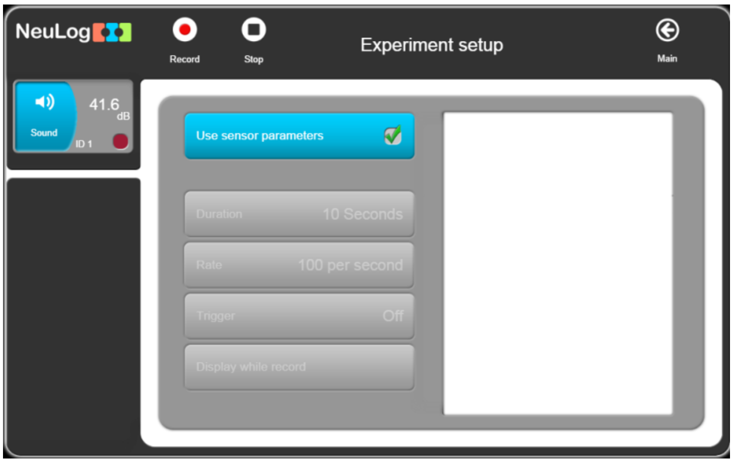
  Two buttons are used to define the experiment duration: Number and Units.

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



The **Trigger** function will be discussed later.
Selecting (this is the default) the **Display while record** is showing the graph while recording the experiment.

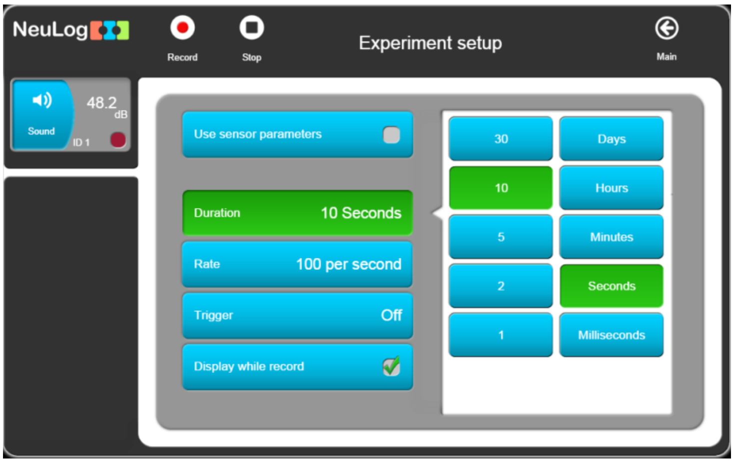
Selecting the Use sensor parameters button will change the screen to the following:



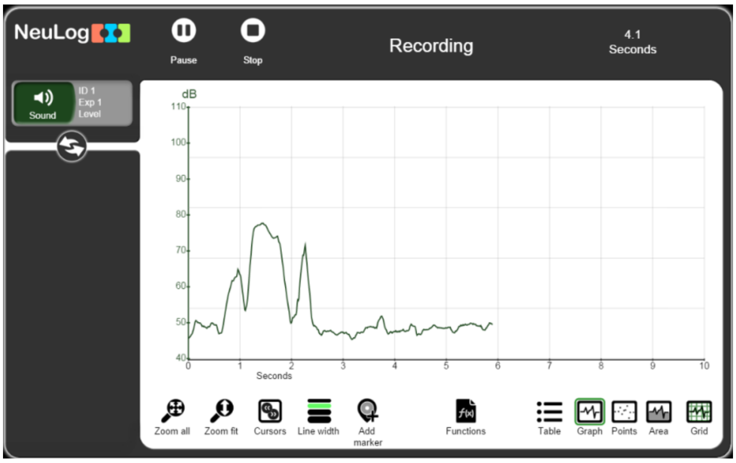
The experiment will run with the sensor setup parameters as described in section 2.5.

3.2 Recording an experiment

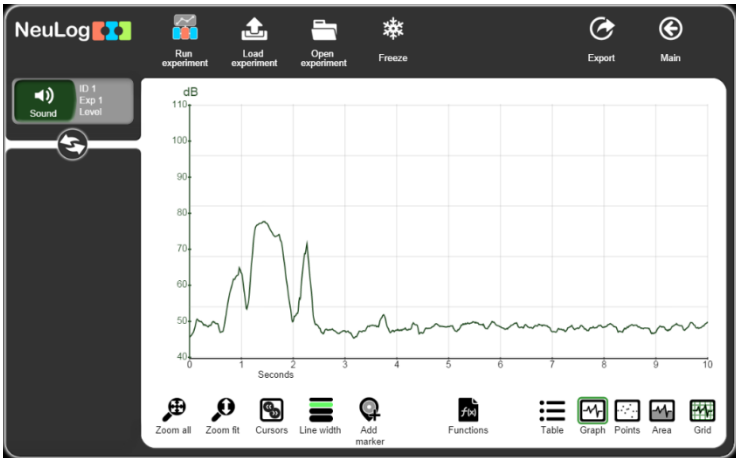
- Unselect the **Use sensor parameters** and define Duration of 10 seconds and Rate of 100 samples per second as in the following screen:



- Press on the **Record** button to run an experiment. While running an experiment, the **Stop Experiment** button is displayed. The experiment graph is built online. The experiment can be stopped before it is finished by pressing the "Stop Experiment" button.

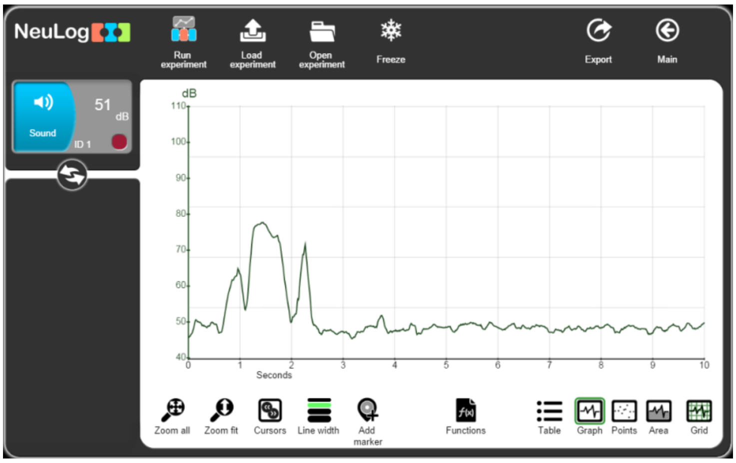


When the experiment is ended, the following screen will appear:



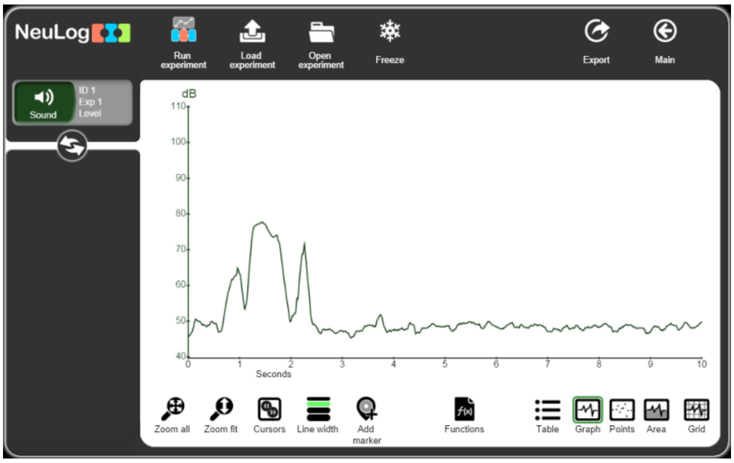
The graph sensor buttons on the left gives the information about the experiment graphs that shown on the window. No measuring values appear on these buttons.

- Click on the double arrows button and this will replace the graph sensor buttons with live sensor buttons.



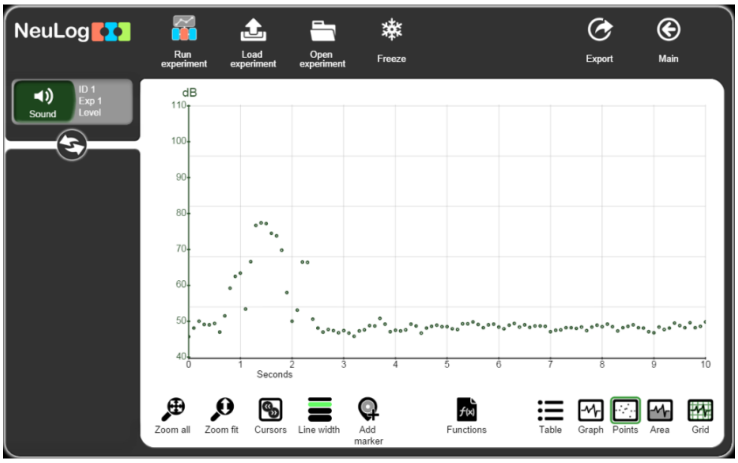
- Click on the double arrows button again and this will replace the live sensor buttons with graph sensor buttons.

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

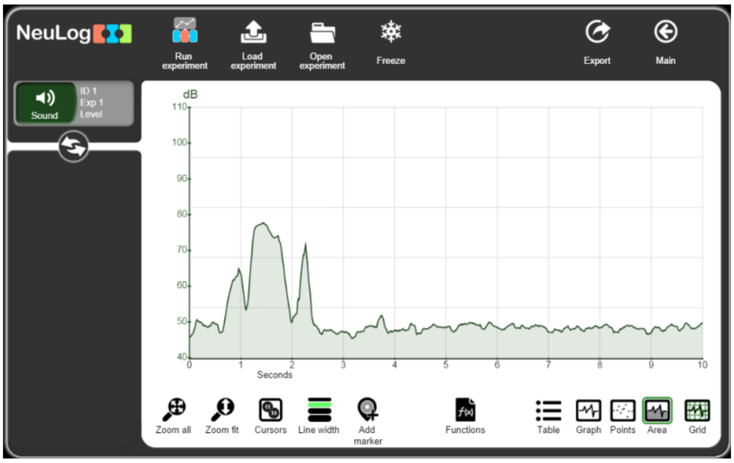


- Press on the **Grid** button to show again the vertical and horizontal lines of graph.

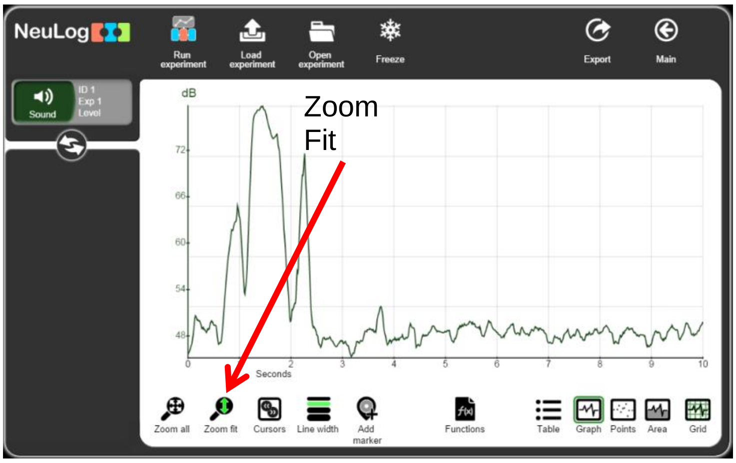
- To convert a graph to a series of points, press on the **Point** button. To return to the regular graph mode, press on the **Graph** button.



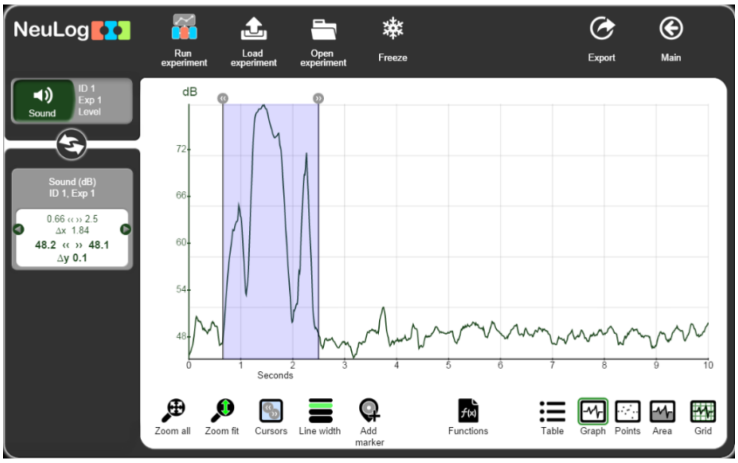
- To show the area below the graph, press on the **Area** button. Press on the **Graph** button to cancel this command.



- The **Zoom Fit** button adapts the graph axes and expands them accordingly.

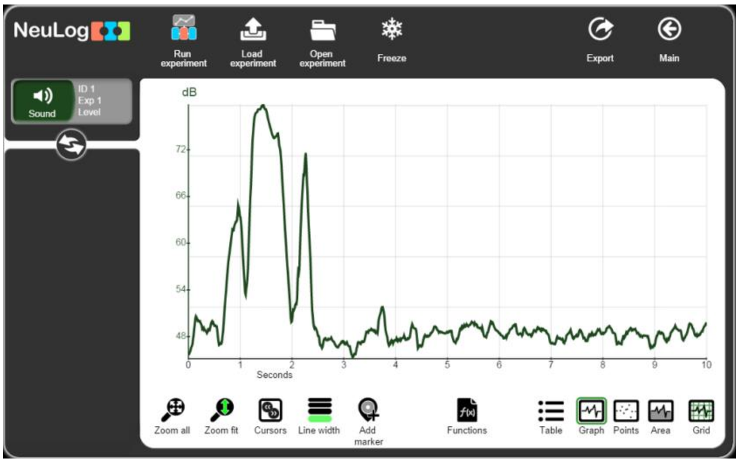


- Press on the **Cursors** button to choose the segment of the graph of interest. The result of the expanded graph segment is shown below.

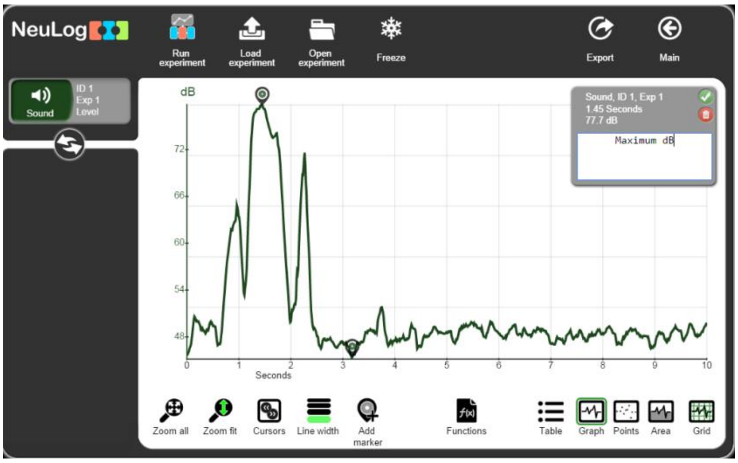


Each cursor can be dragged to the right or to the left. The parameters on the left column will be changed accordingly.

- Clicking on the Line width will change the graph line width.

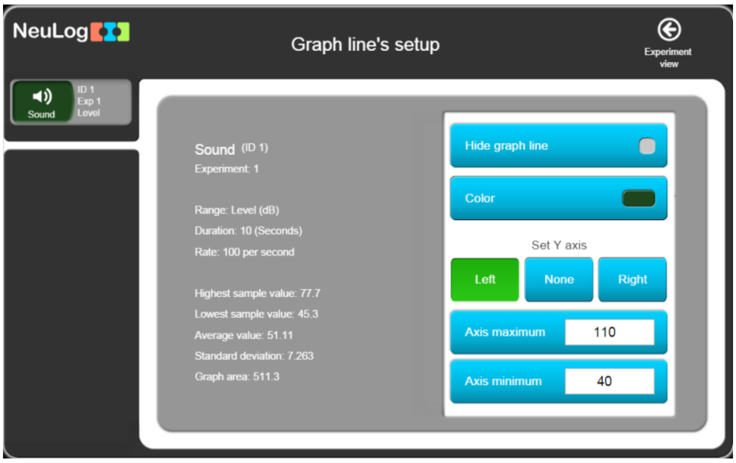


- Markers can be added to certain points on the graph for describing them.



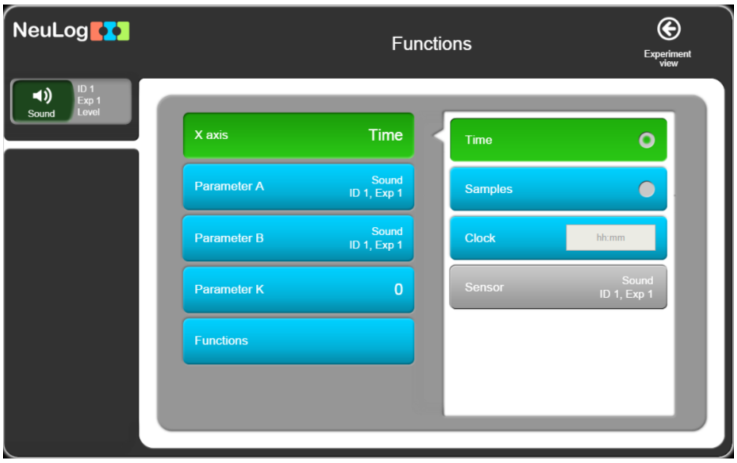
- Pressing the garbage box will delete the marker.

- Clicking on the graphsensor box on the left will show the following screen:



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

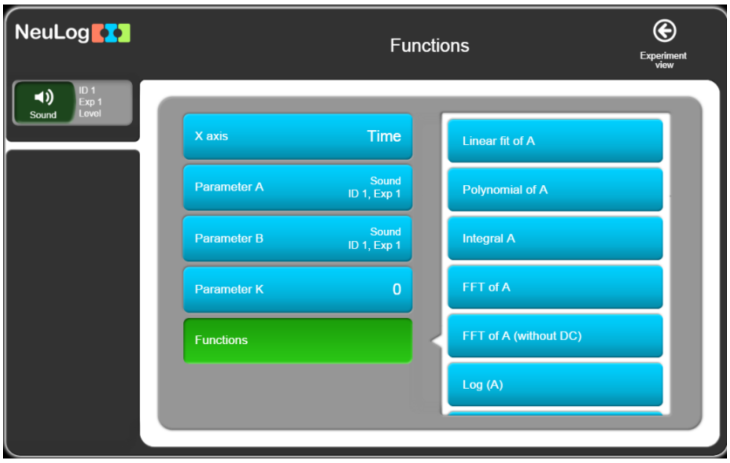
- The **Functions** button enables to manipulate mathematical functions on the graph.



- The options of the X axis button are: Time (default), samples, clock or sensor (XY graph when more than one sensor is participates in the experiment).

- The manipulating function can be operated on one sensor (defined as parameter A), on two sensors (the second one is defined as parameter B), on a constant value (defined as parameter K) on a sensor (parameter A).

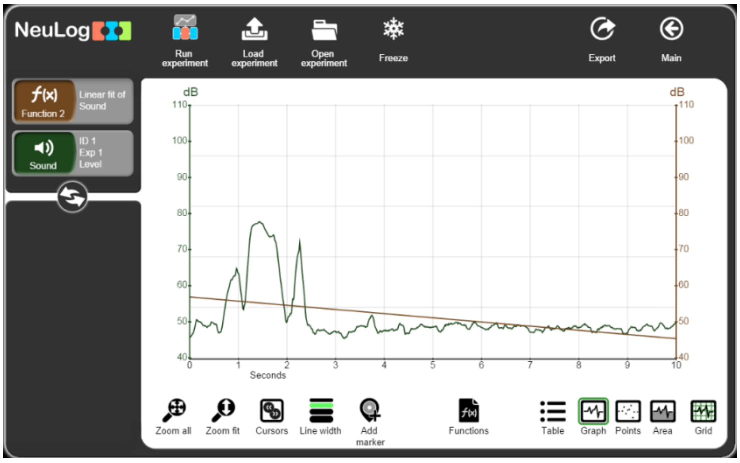
- The Functions button opens the following list of functions:



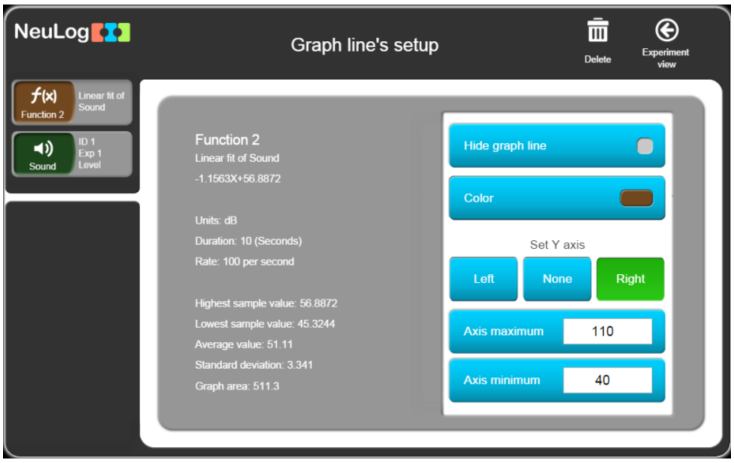
The optional functions are:

• **Integral A,**	• **e^A,**
• **Linear fit of A,**	• **10^A,**
• **Polynomial of A,**	• **Add K to A,**
• **FFT of A,**	• **Multiply A by K,**
• **FFT of A (without DC),**	• **Divide A by K,**
• **Log(A),**	• **Add A to B,**
• **Ln(A),**	• **Subtract B from A,**
• **Square root of A,**	• **Multiply A by B,**
• **A^2,**	• **Divide A by B,**
• **1/A,**	• **Divide dA by dB,**
• **1/(A$^{2)}$,**	• **Divide dA by dB^2,**

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

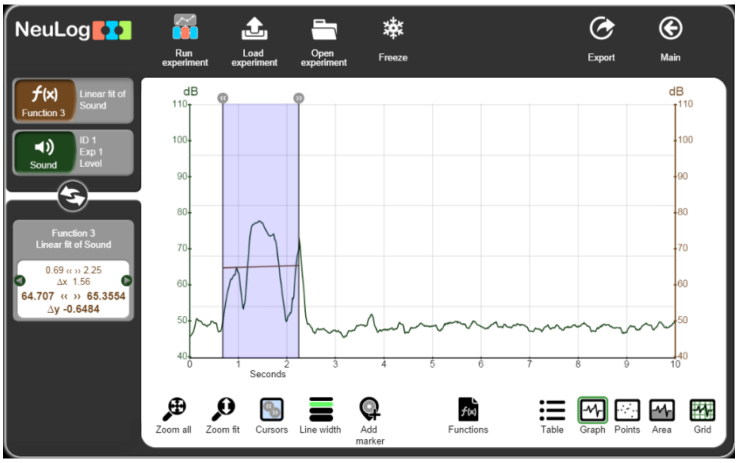


- The formula of the linear fit graph can be fined in the data screen of the function 2 graph symbol:

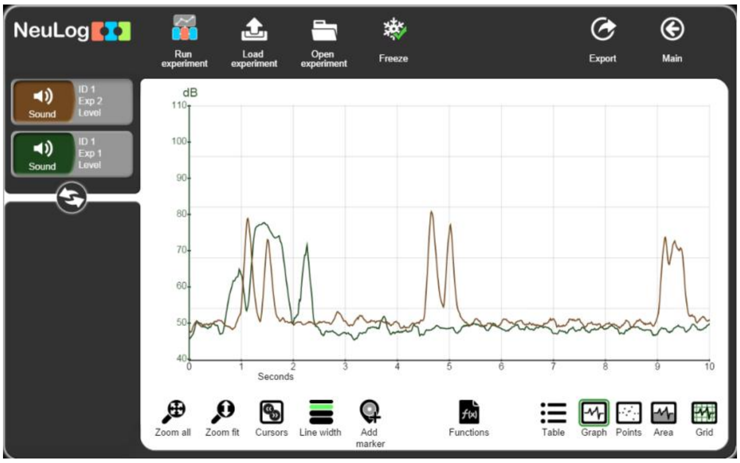


- The graph can be deleted by clicking on the garbage box on the right on the top.

- When a range is defined by cursors, the function is manipulated on the defined range only, as below:

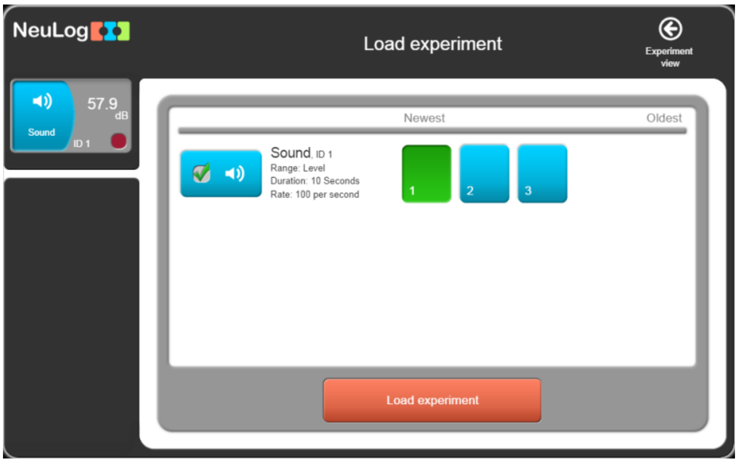


- Clicking on Freeze and running a new experiment, will show the two experiment graphs:

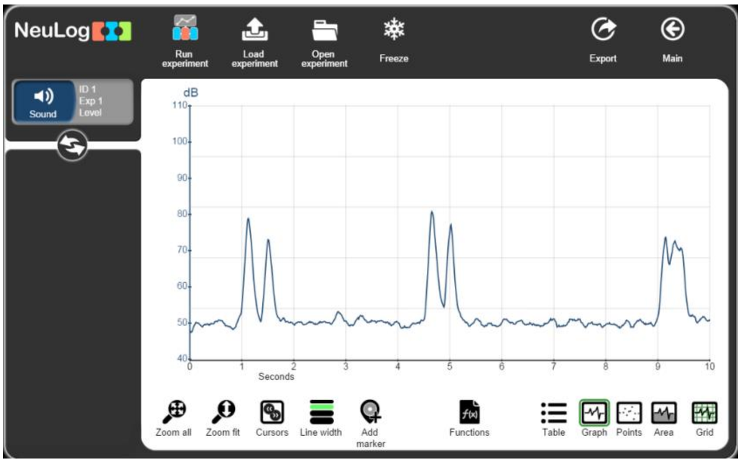


- Every sensor saves the experiment in its flash memory while sampling. The sensor can save up to 5 experiments.

  The Load experiment button open the following screen for loading experiment from the sensor flash memory:

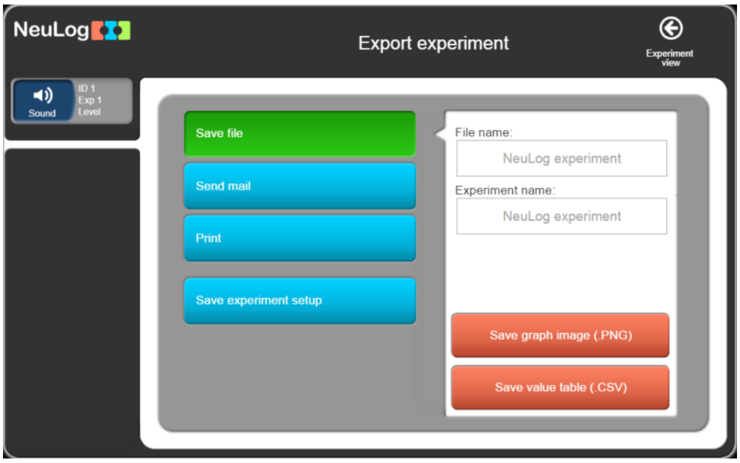


- Select the required experiment and press the Load experiment button and the experiment data will be loaded from the sensor.



3.3 Save and open

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



- The NeuLog saving format is CSV format for opening it also under spreadsheet program (like Excel™).

  The experiment is a name that used as a title for the experiment.

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

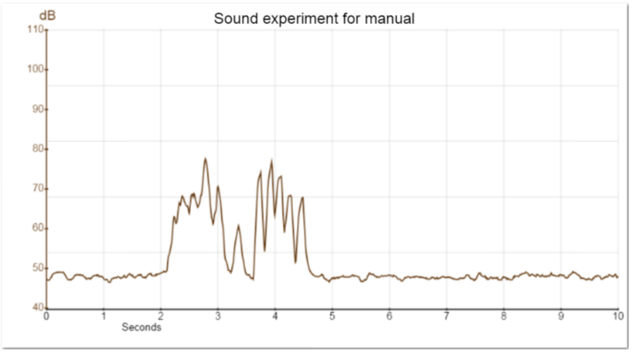
- A dialog box is opened.
  Browse to the required directory and press **Save**.

- This is a CSV file and it will also appear on the bottom left of the screen.
  Clicking on it will open it under spreadsheet program.

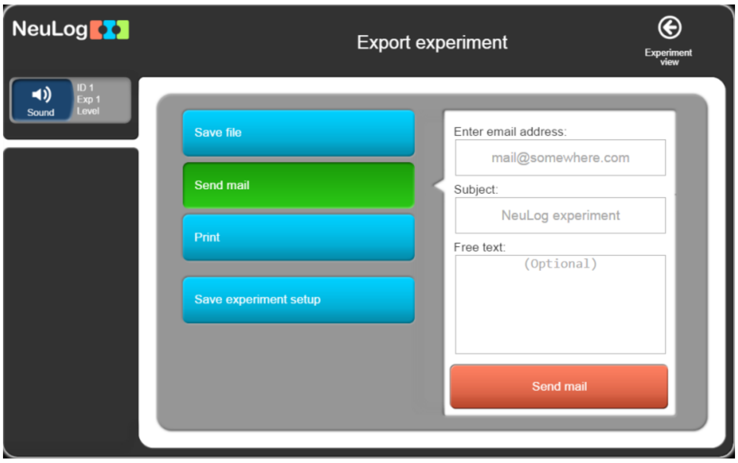
- The experiment can also be saved as a picture (.PNG) of the graph.

- A dialog box is opened.
  Browse to the required directory and press **Save**.

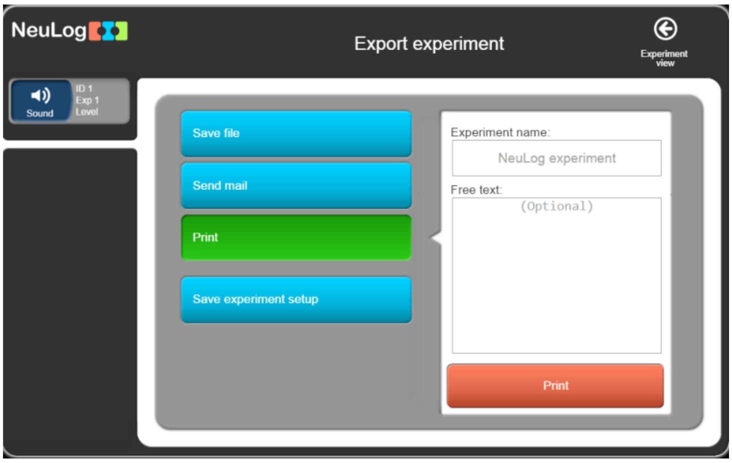
- This is a .PNG file and it will also appear on the bottom left of the screen.
  Clicking on it will show the picture of the graph on the screen..



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

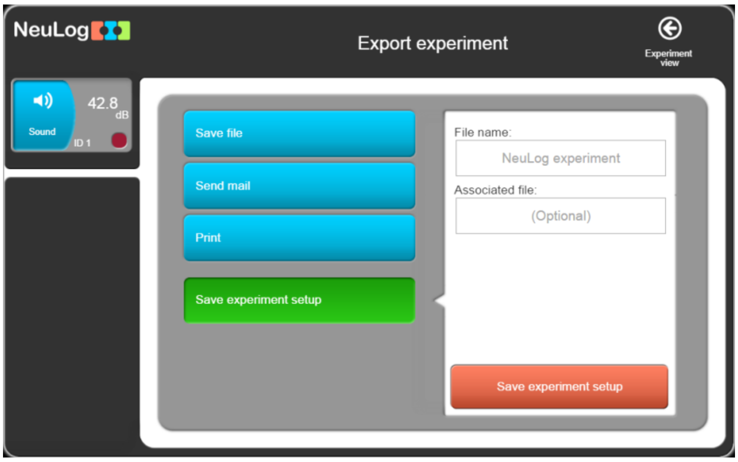


- The graph can also be printed by clicking on the **Print** button



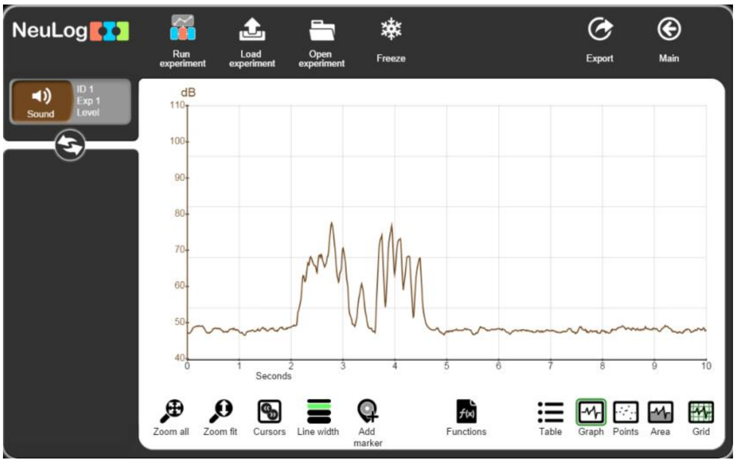
- The experiment parameters (such as sensors' ranges, duration, rate, trigger values) can be also saved as a file by clicking on the Save experiment setup button.

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



- Press Back.

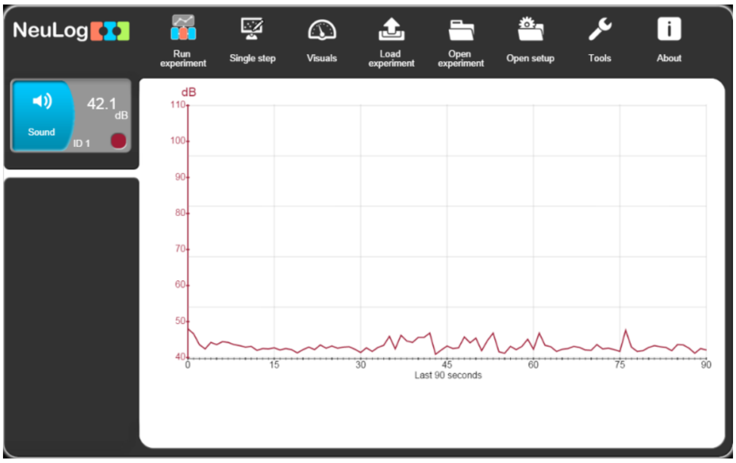
- To open an experiment, press on the **Open Experiment** button.
  An explorer dialog box is opened.
  Browse to the download files library and select the file you have saved.



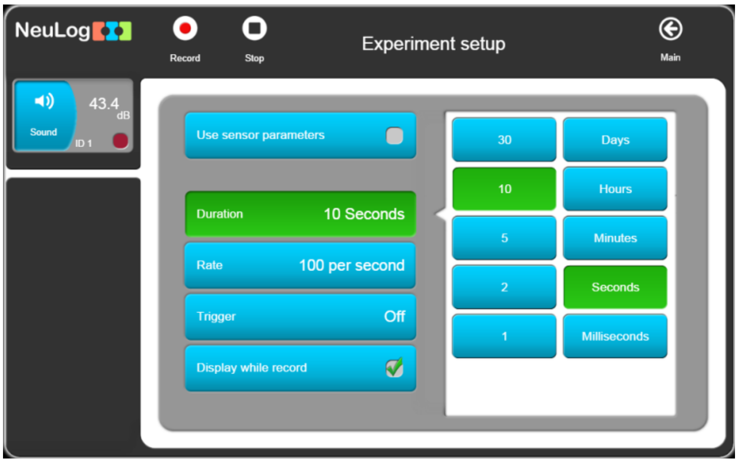
The graph can be freezed and another experiment can be opened or loaded from the sensors for comaparing between experiments.

3.4 Experiment with trigger

- Return to the main screen



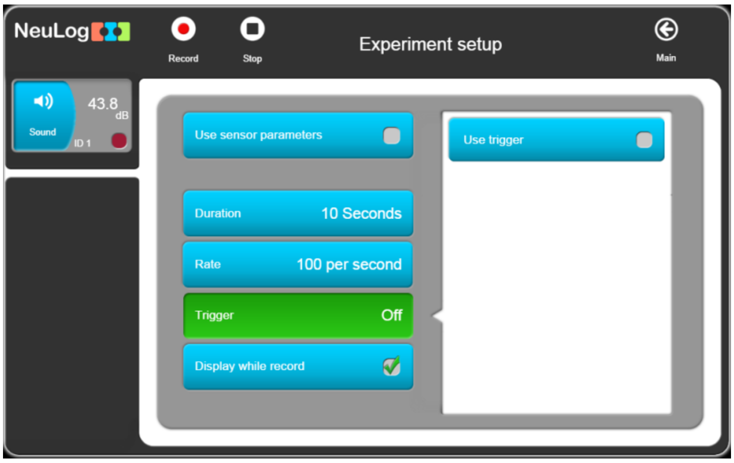
- Click on Run experiment button



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

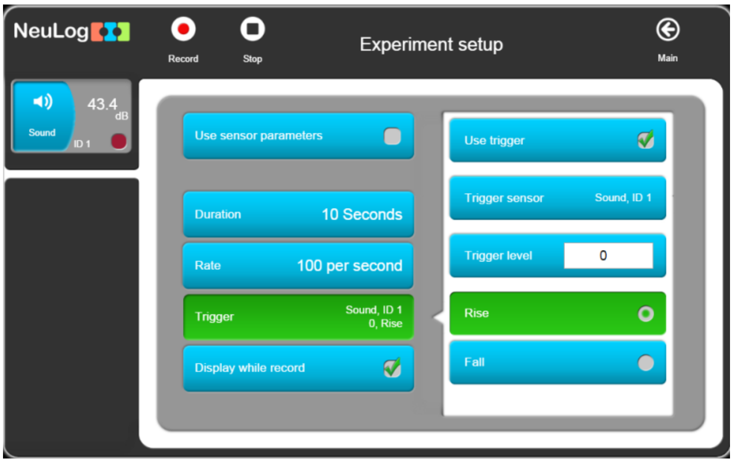
  The trigger can operate on either a rising or falling sensor signal.

  Click on the **Trigger** button



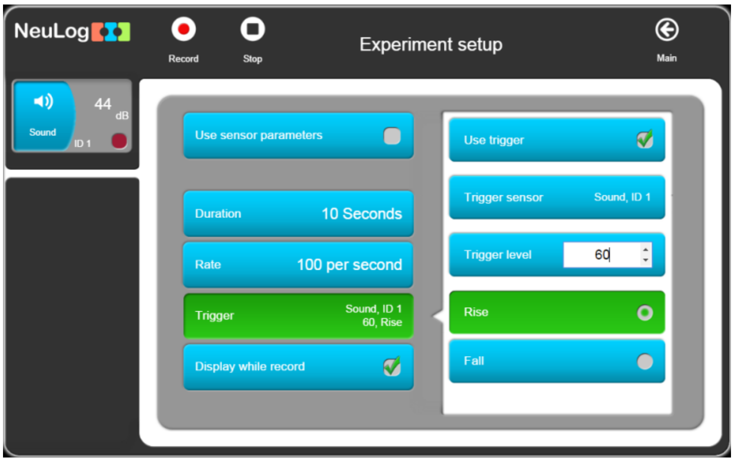
- Select the Use trigger button

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

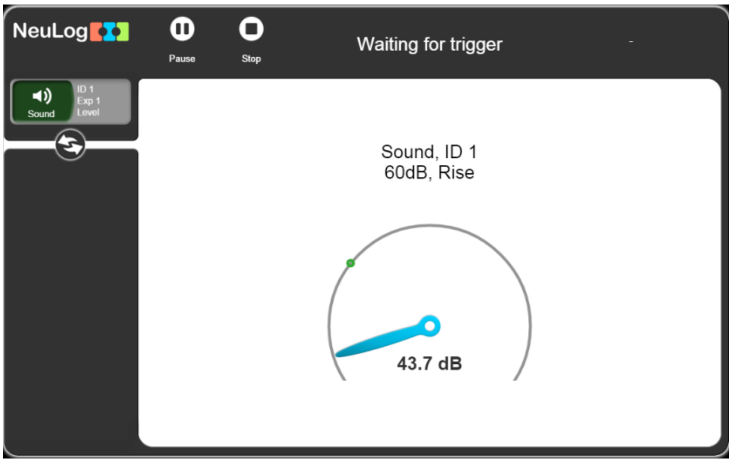


- Enter the 60 as level value and select 'Rise'.

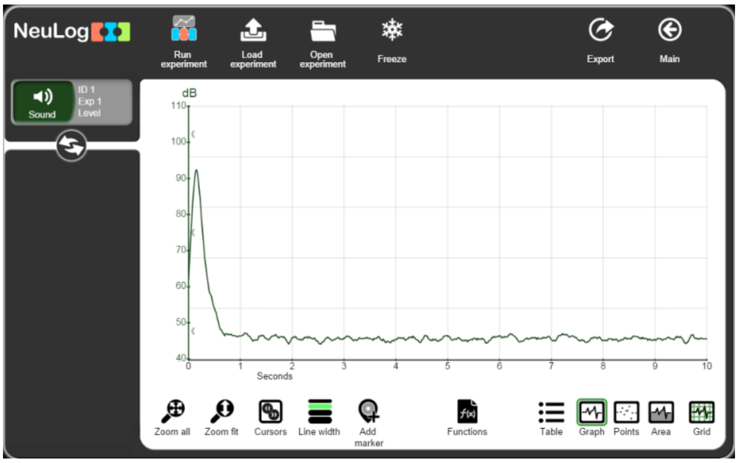
- The following shows the experiment setup menu after the experiment parameters including the trigger have been defined.



- After pressing '**Record**', the following screen appears displaying the **Waiting for Trigger** message when waiting for trigger to start sampling.

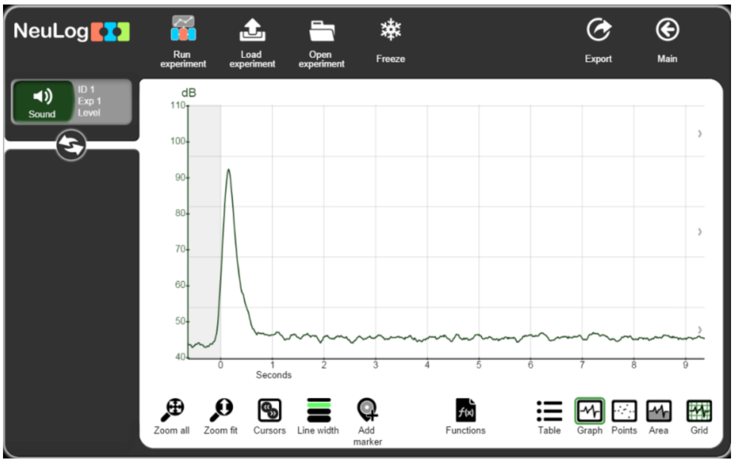


- Make a noise above 60dB and the graph will appear on the screen.

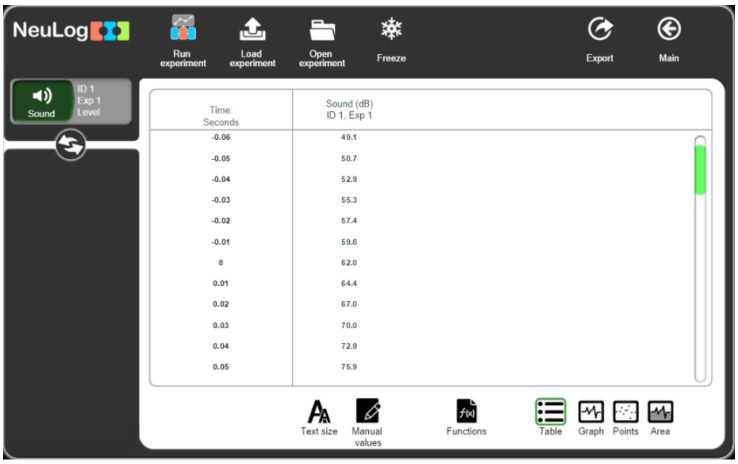


- Pay attention at what level the graph starts.

- The system saves samples also before the trigger is received.
Click with the left mouse button anyway on the graph window, keep it pressed and pull it to the right.



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

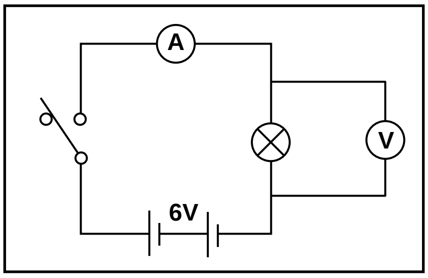


To return to the graphic display, press on the **Graph** button.

3.5 Experiment with more than one sensor

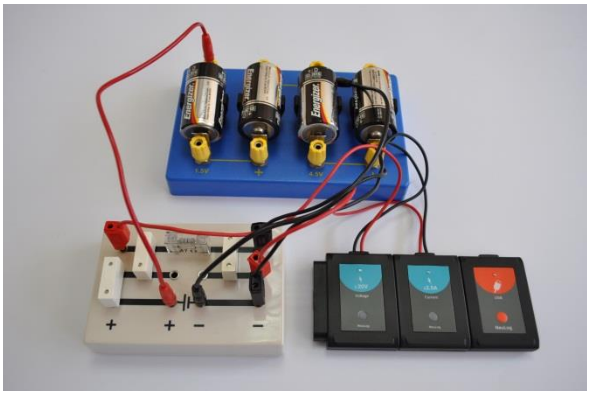
There are a number of experiments in which two sensors are used and their data plotted, not against Time, but with what the two sensors have measured plotted against each other. Examples of this are graphs of (i) the Voltage across a component (e.g. resistor, light emitting diode or bulb) against the 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 will be looking at the first of these two examples as a small filament light bulb is switched on.

You will be connecting up the circuit shown below.



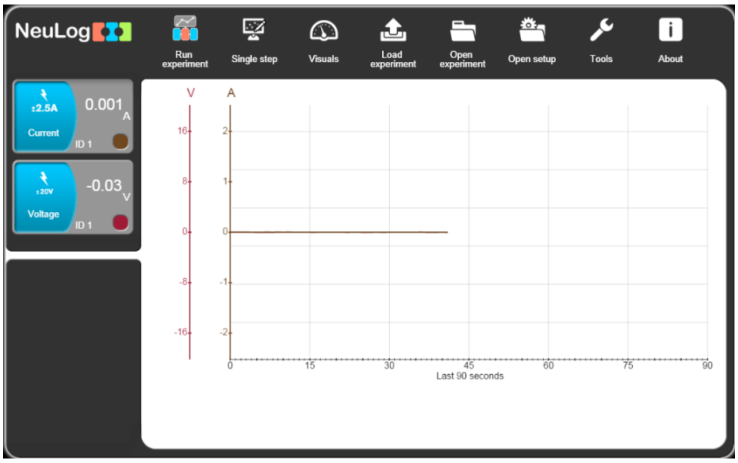
Circuit diagram

This circuit is ideally mounted on a box 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 an m.e.s. tubular 6.5V 300mA. The battery should be a 6V one and here it has been placed inside the box. A photograph of such a setup is shown below.

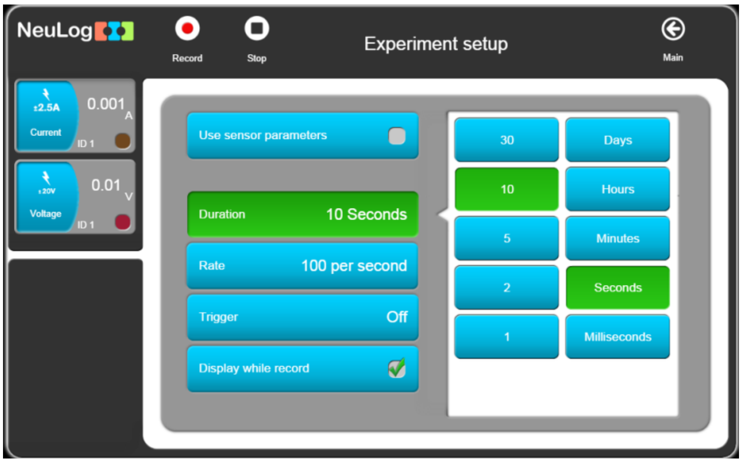


- Connect a **Voltage sensor** to the **USB Bridge module**.
- Connect a **Current sensor** to either the **USB Bridge module** or to the **Voltage sensor**.
- Plug the Voltage sensor's red and black 4mm plugs into the sockets across the bulb, red plug to red socket and black plug to black socket.
-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

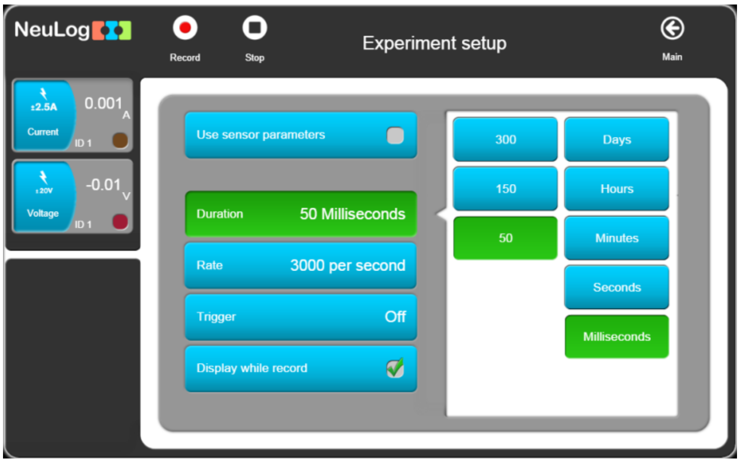
- Enter the **NeuLog™** main screen and the Voltage and Current sensor modules are displayed as shown below.



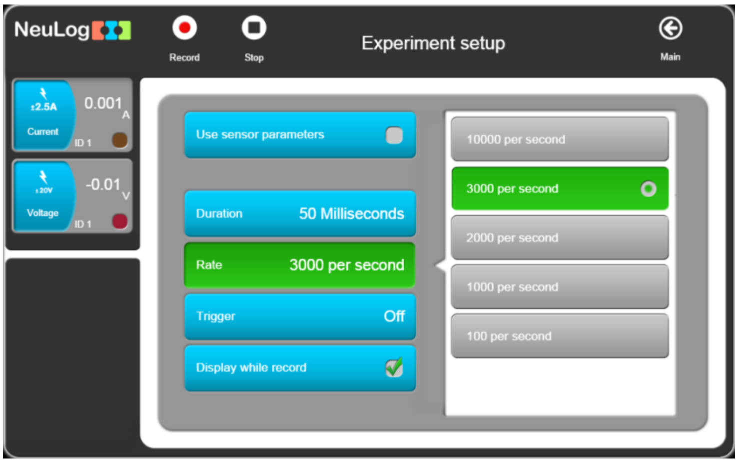
- Click on the **Run experiment icon**  in the Main-icon bar to display the Graph window below.



- The switching **on** of the bulb is a very fast event, so select '50 milliseconds' for **Experiment duration**.



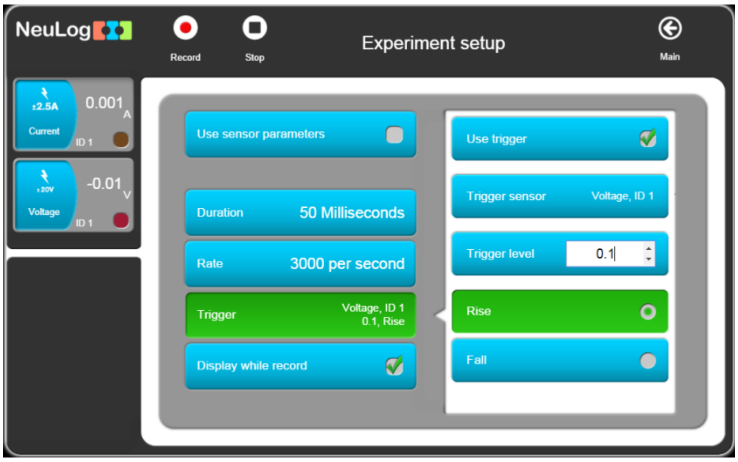
- Now select '3000 per second' for **Sampling rate.**



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

To trigger the start of sampling you will make use of the rise in voltage across the bulb as the switch is closed.

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

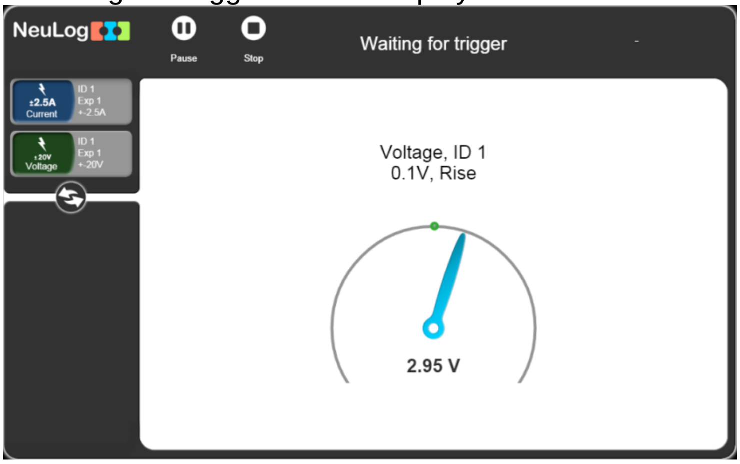


Alternatively you could have set the Trigger so that it is based on the Current sensor, Current 1, rising to a level of say 5mA.

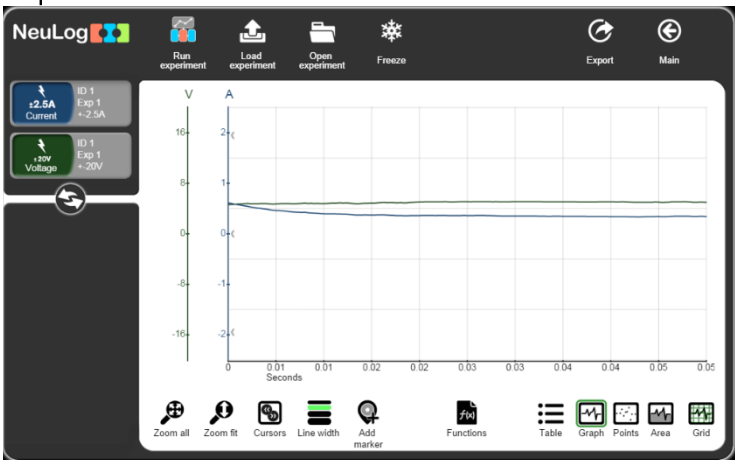
At this stage it is useful to first see each of the graphs plotted against Time.

Click on the **Record icon** 

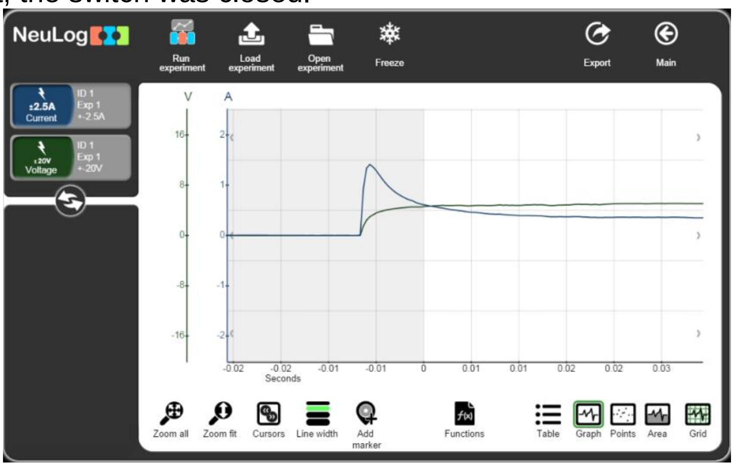
- . The message 'Waiting for Trigger ' will be displayed on the screen.



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

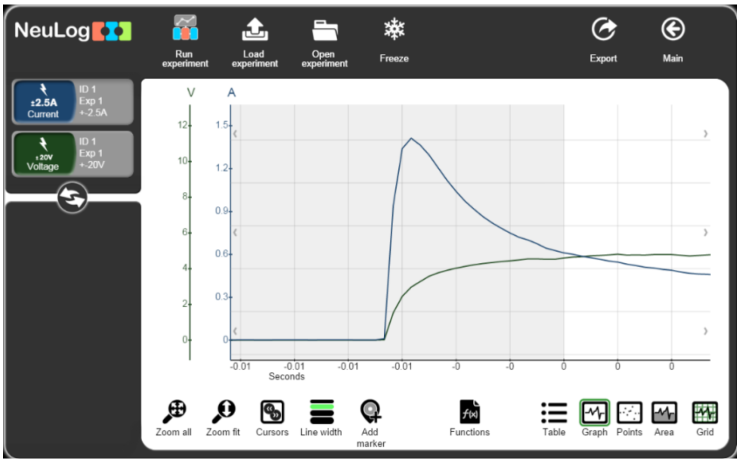


- Drag the graph to the right to observe the pre-triggering area so that they display what was happening to the current through the bulb, and the voltage across it, just before and at the moment, the switch was closed.



The interesting section of the above graphs is obviously just before the bulb was switched **ON** to when the bulb was fully lit where the two graph-lines level off. So it is useful to be able to examine this section in more detail and you will see how to do this on the following page.

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

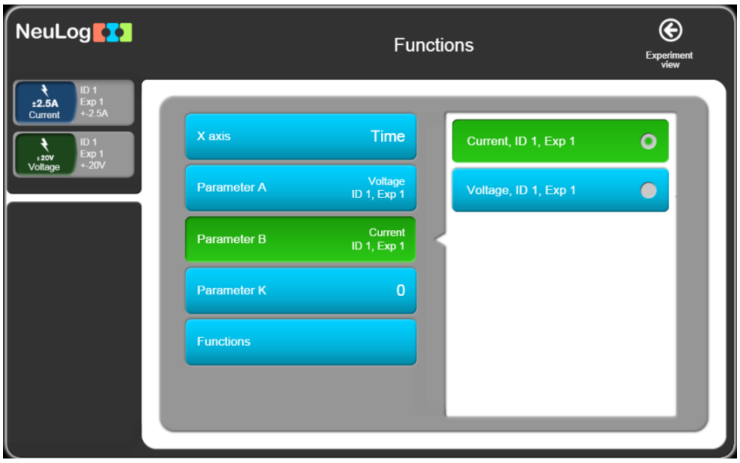


3.5.1 Using the functions (math tab)

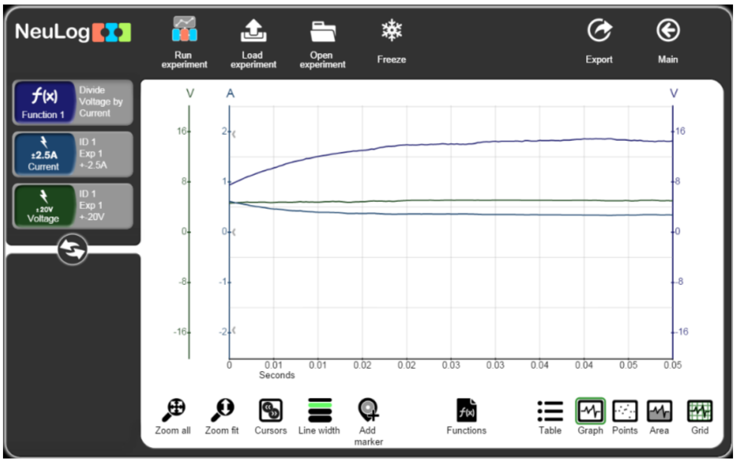
With both voltage and current data available you can now obtain a graph of how the resistance of the bulb changed with time by generating a graph of (voltage across the bulb ÷ current flowing through the bulb) plotted against Time. The math tab window of the functions window provides a number of mathematical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

For the case that there are more than one sensor, it is possible to analyze the measured results with mathematical functions for two sensors after pressing on the **Functions**  Button.

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

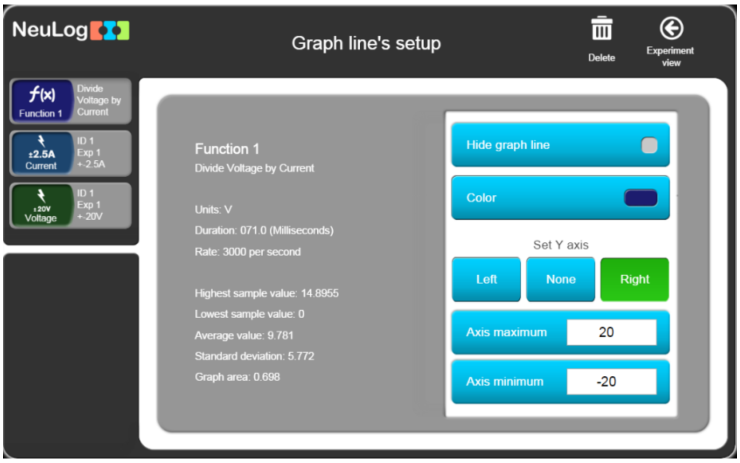


- Click on the **Divide A by B** button and you should now see displayed the original graphs of Voltage against Time and Current against Time, and an additional graph (in blue) of Voltage/Current against Time as shown below.



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

- Click on the f(x) button for the following screen:

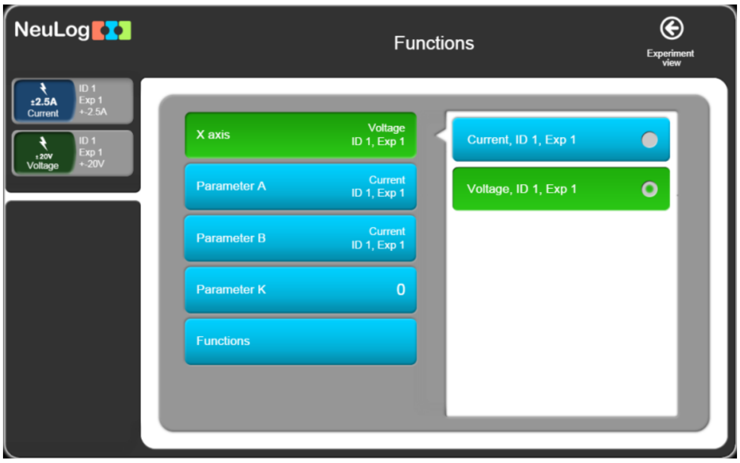


- Click on the garbage box to delete this graph.

3.5.2 Plotting an XY graph

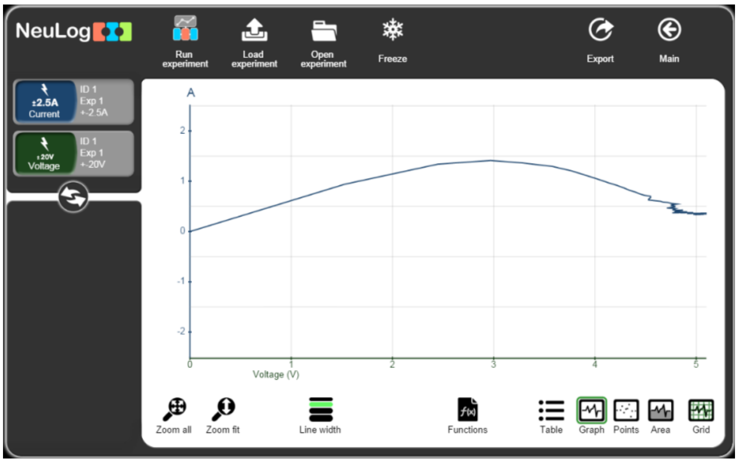
Up until this point, running the experiment has resulted in graphs of 'Voltage across the bulb against Time' and 'Current through the bulb against Time' being plotted separately. This done, you can now plot what is known as an **XY graph** with the 'Voltage across the bulb' on the X-axis and the 'Current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

- Click on the Back to experiment view button.



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 goes down because the bulb resistance increase when the bulb temperature increases.

Alternatively you could have plotted 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

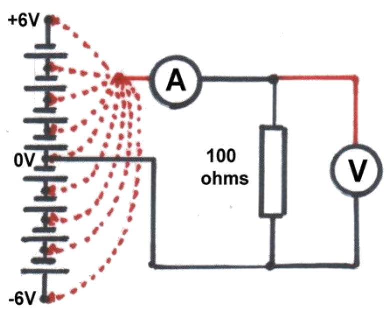
An experiment can be run taking and recording measurements only when you wish to do so.

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

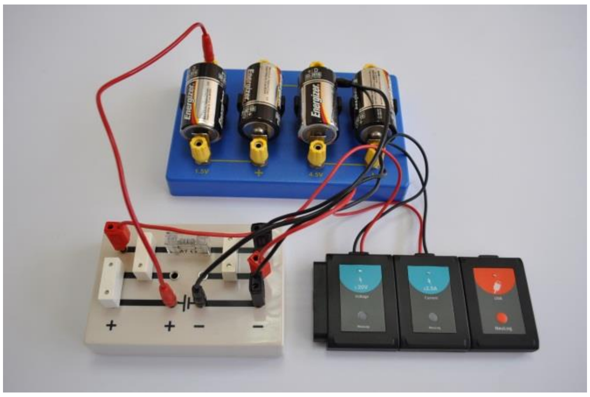
This mode will be used when what is, or are being measured, are discontinuous or do not change as a function of Time. It may be that you wish to record the temperatures of a range of different soil or sand samples that have been exposed to the Sun for an hour. You would simply insert a Temperature sensor  into each sample in turn and record their temperatures into a table by repeatedly clicking on the **Single step icon** . A graph of the data would probably not be useful, though if one was plotted its X-axis would display 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 100Ω resistor, a diode, a 6V MES filament bulb and a light emitting diode (led), vary with applied voltages of approximately 0V, ±1.5V, ±3V, ±4.5V and ±6V, provided simply by two sets of cell holders. Such a setup does not require a continuously variable voltage supply and so 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 100Ω resistor.

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

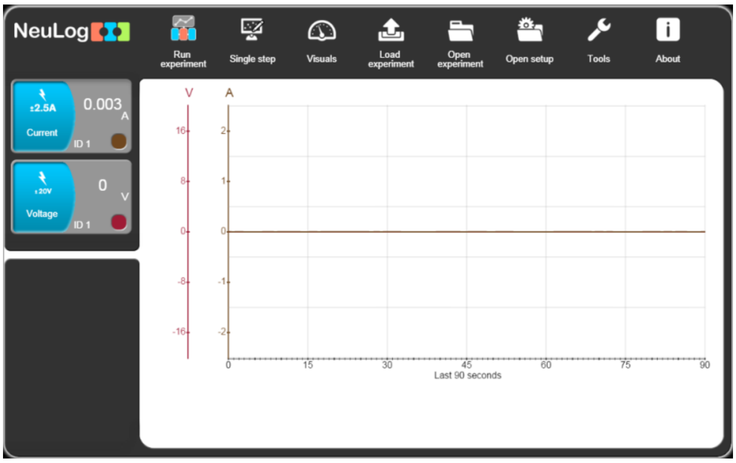


Circuit Diagram



Apparatus Setup

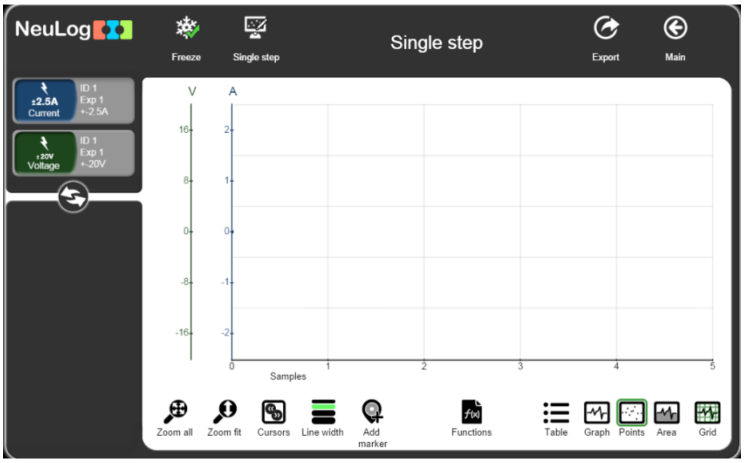
- Enter the **NeuLog™** main screen and the Voltage and Current sensor modules are displayed as shown below.



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

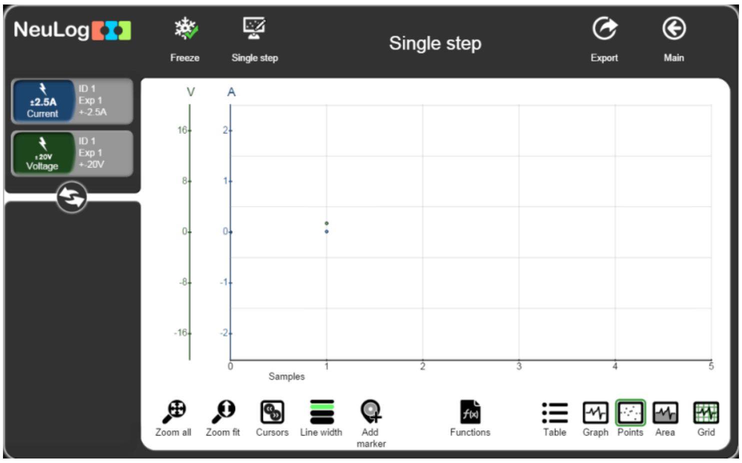
The Voltage Sensor's Module box should now display a value around '0V' and the Current Sensor's Module box a value around 'A'.

- Click on the **Single step icon**  and the first plot will be displayed as shown in the Graph window below.

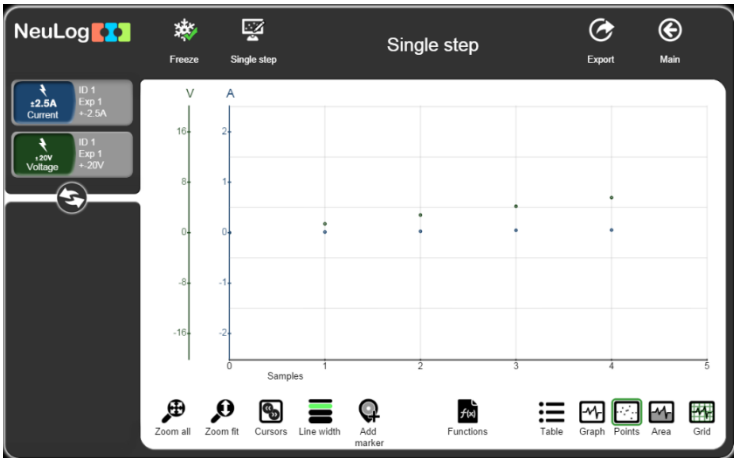


- Now move the Voltage sensor's red plug into the 1.5V socket of the lower cell holder.

- Click on the **Single step icon**  in the Sub-icon bar.

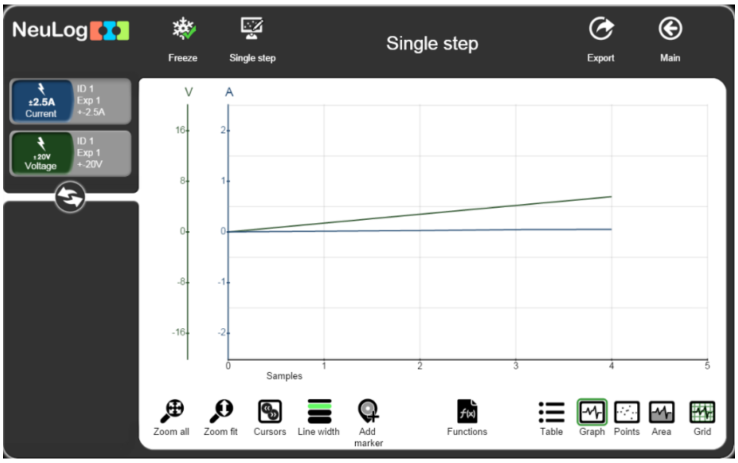


- Repeat the process of moving the Voltage sensor's red plug into the +3V, +4.5V and +6V sockets of the cell holders, clicking on the **Single step icon**  in the Sub-icon bar after each move.
-
- You should have a graph similar to that shown below.

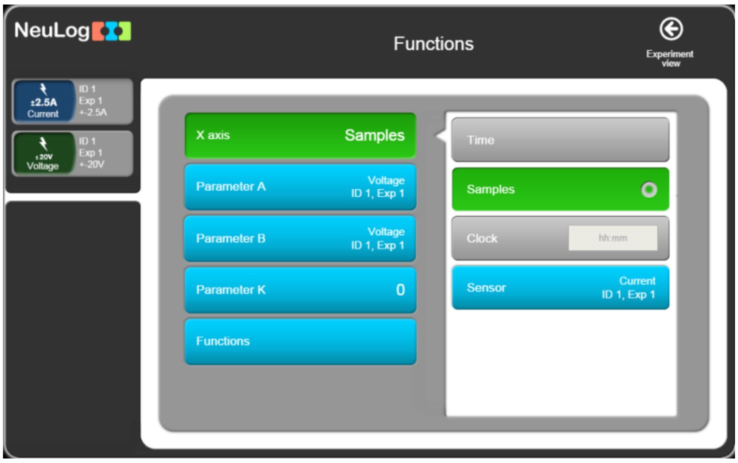


- Remove the Voltage sensor's red plug from the 6V socket of the upper cell holder.

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

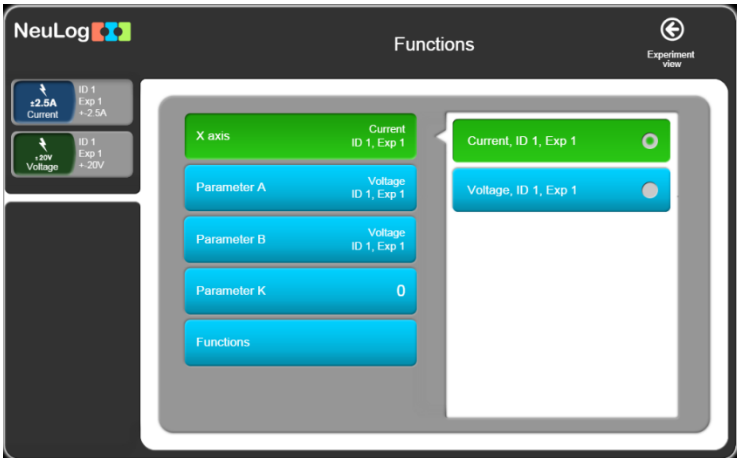


- Another display option for more than one sensor is to plot the measured results for one sensor along the X axis (instead of time); all the other sensors will be plotted on the Y axis in relation to the X axis. Click on the **Functions** button.



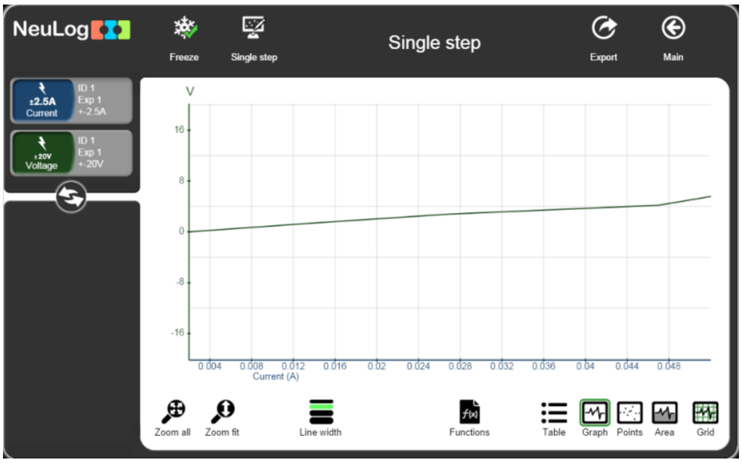
- Note that X axis is sample and not time.

- Change X axis to the Current sensor



- Click on Back to experiment view button.

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

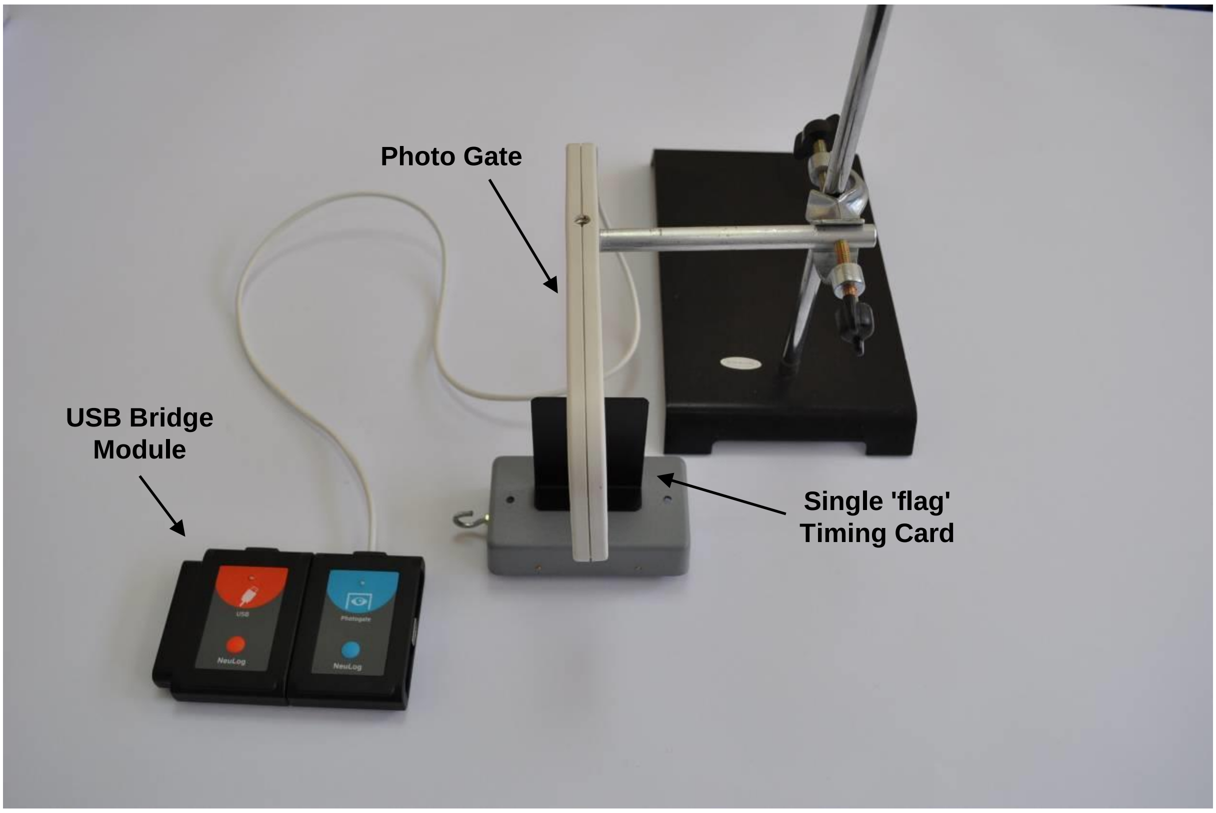


- Click on the **Zoom Fit** button in order to expand the graph.

3.7 Using photo gates

Photo gates are used to measure the Time(s) for which their infrared beams are interrupted. By inputting the length(s) 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 100mm 'flag' and another with two 50mm 'flags' separated by a 40mm gap as shown below, and another 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.

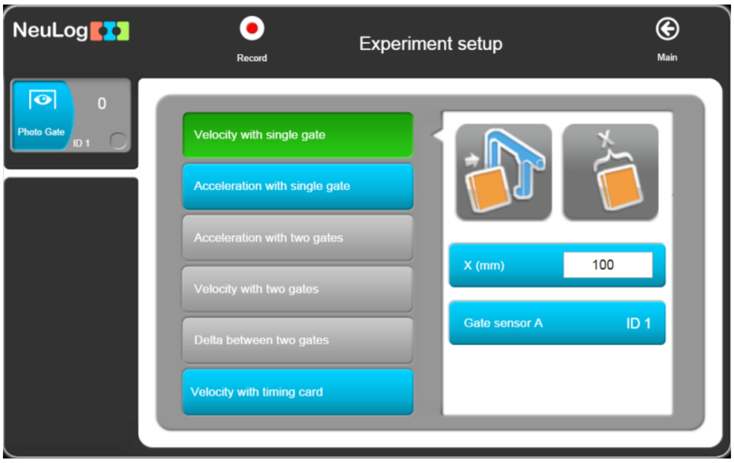
- Fix a photo gate sensor on a retort stand using a bosshead and position it half-way down the runway and such that the timing card will interrupt its beam.

- Connect the **Photo gate sensor**  to the **USB Bridge Module** .

The arrangement of the equipment should be much like that in the photograph above.

- Enter the **NeuLog™** main screen and the Photo gate sensor module displays in the Module window as shown below.

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



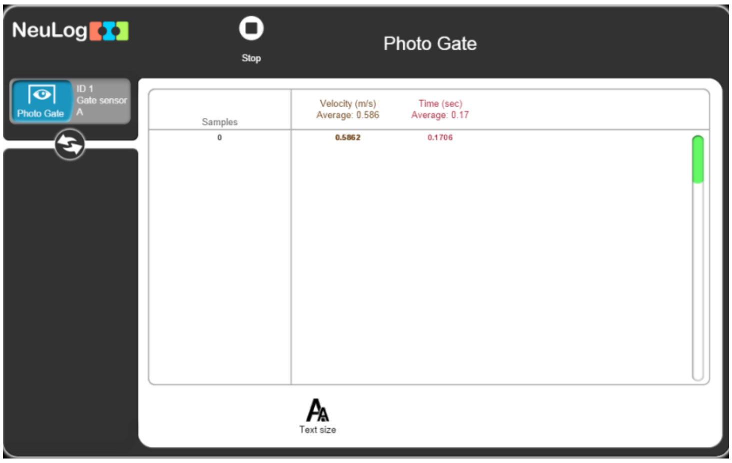
There are three options of experiments with one photo gate: **Velocity with single gate, Acceleration with single gate** and **Velocity with timing card**.

3.7.1 Velocity with single gate

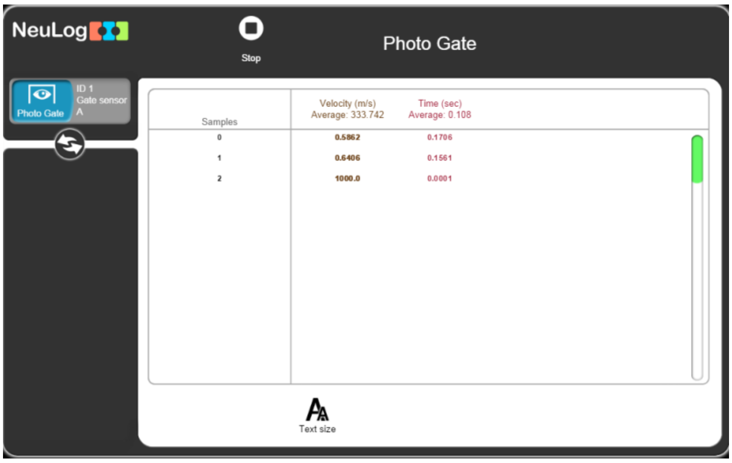
- Set the flag width (X[mm]) to 100 and click on the **Velocity with Single Gate** button.

- Click on the Record icon .

- Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long the Timing card took 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 too.



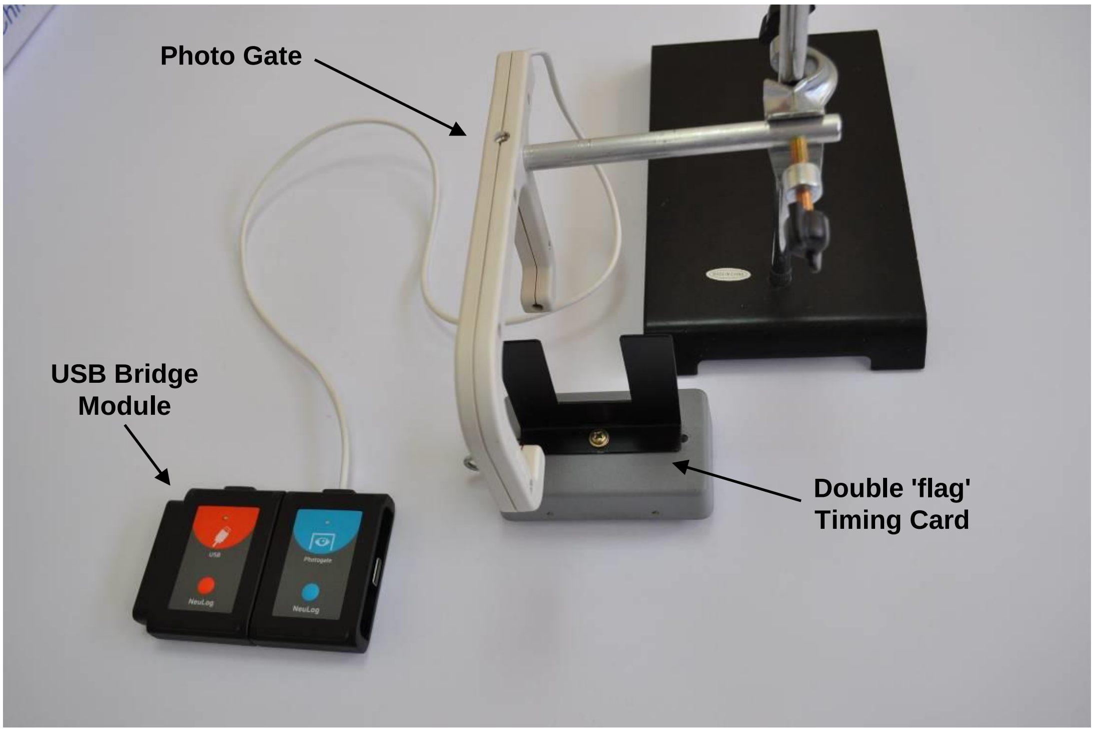
Note that the Table also has velocities recorded as well as times.
The grey first line shows the average time and the average velocity of the samples.

- Click on the Stop experiment icon 

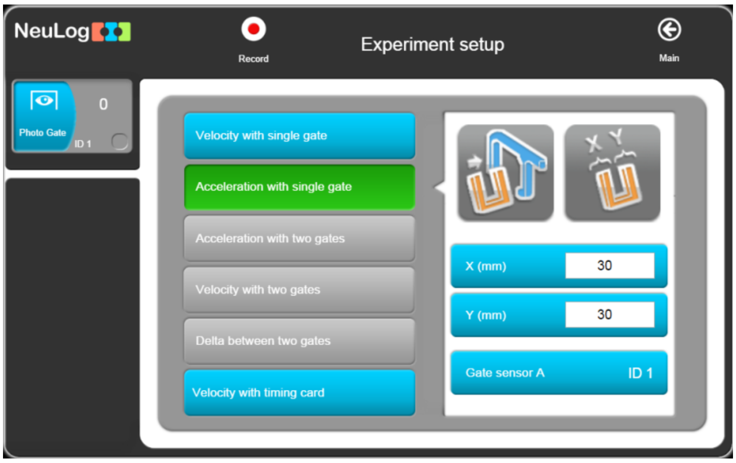
- Return to the main screen.

3.7.2 Acceleration with single gate

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



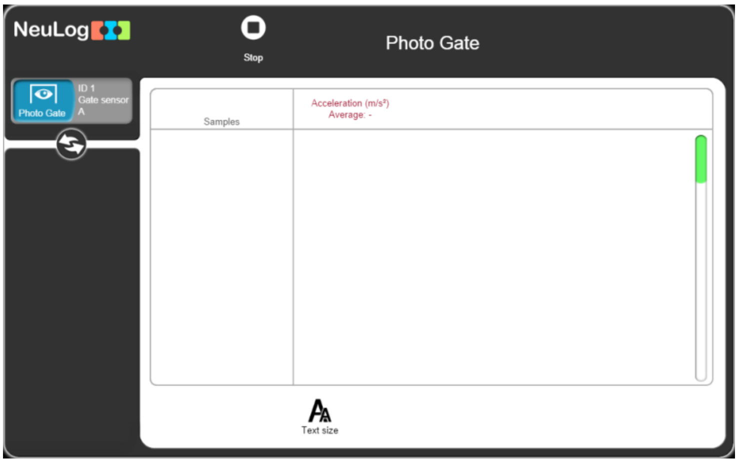
- Attach a Double 'flag' timing card to the model car.
- Now click on the **Acceleration with Single Gate** on the **Experiment Setup**.



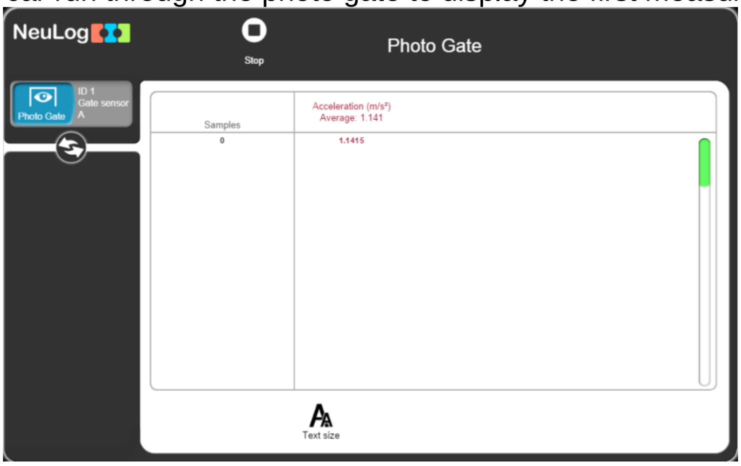
- The system measures the velocity of each flag and divides the difference between the velocities by the time between the flags.

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

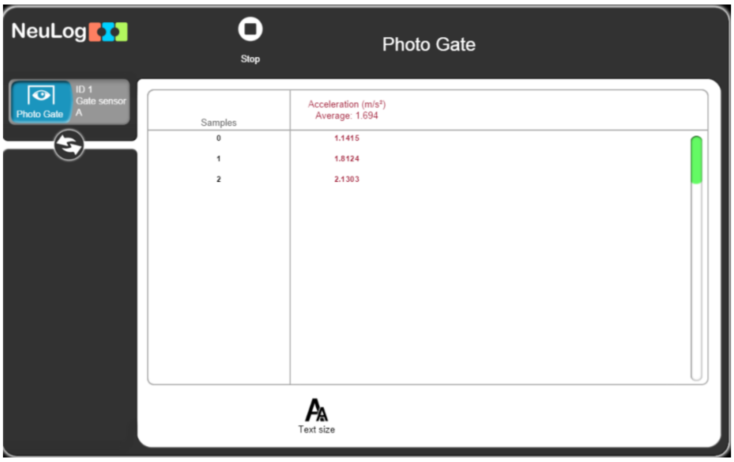
- Click on the Record icon .



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



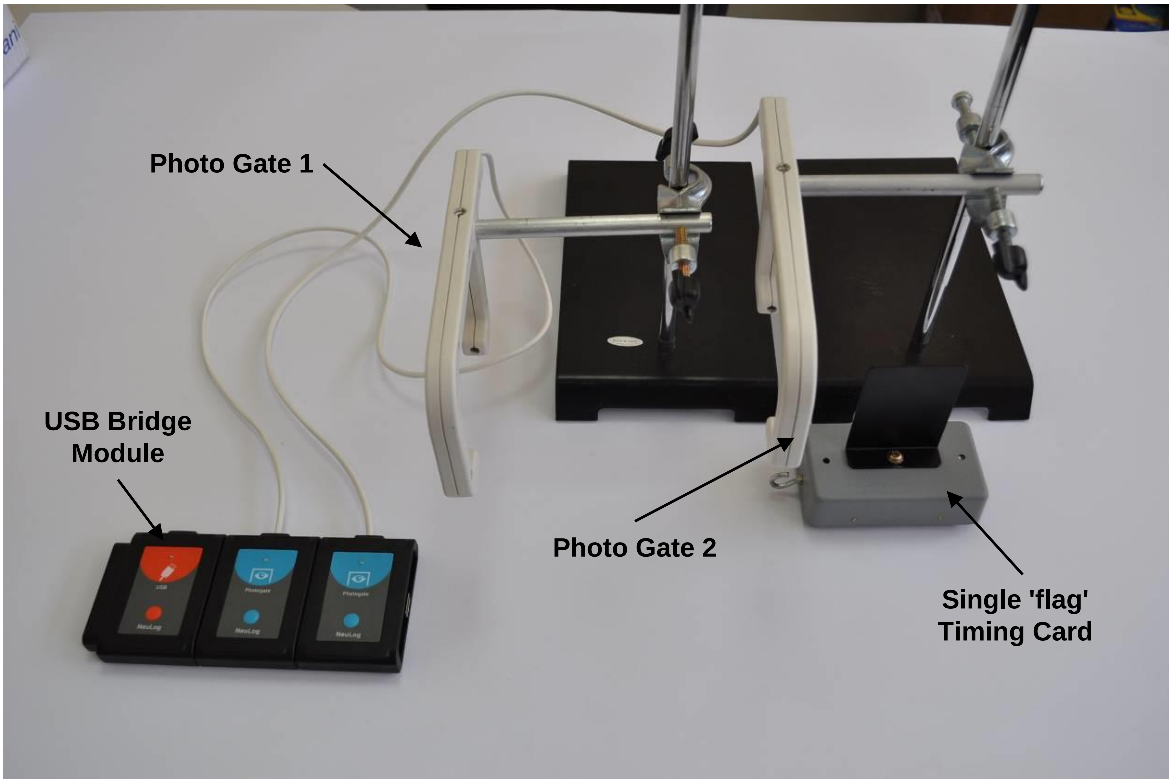
- Repeat **twice** more, releasing the model car from the same position, to obtain a set of measurements similar to those shown below.



- Click on the Stop experiment icon 

- Return to the main screen.

3.7.3 Acceleration with two gates

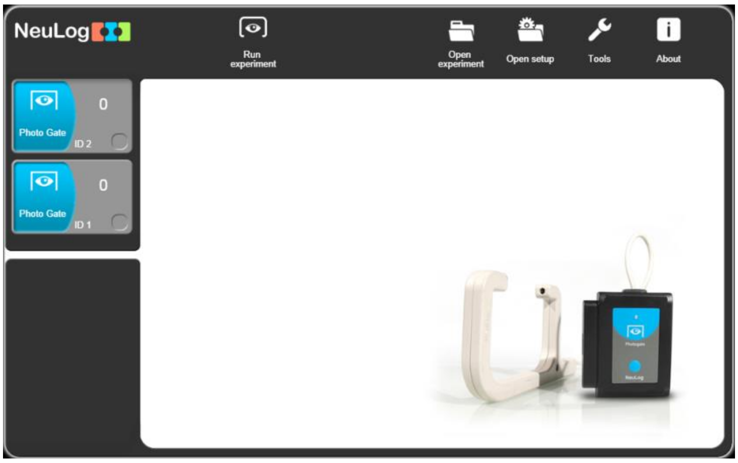


- Replace the Double 'flag' timing card by the Single timing card again.

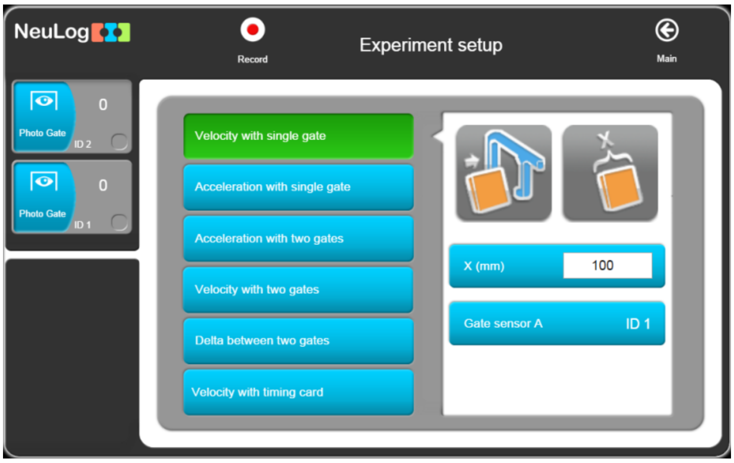
- Connect a further **Photo gate**  to the **USB Bridge module**  and mount its gate slightly lower down the runway. Again check that its height is correct for the timing card being able to break its beam.

The apparatus should appear much as in the photograph.

- Wait to get the following screen.



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



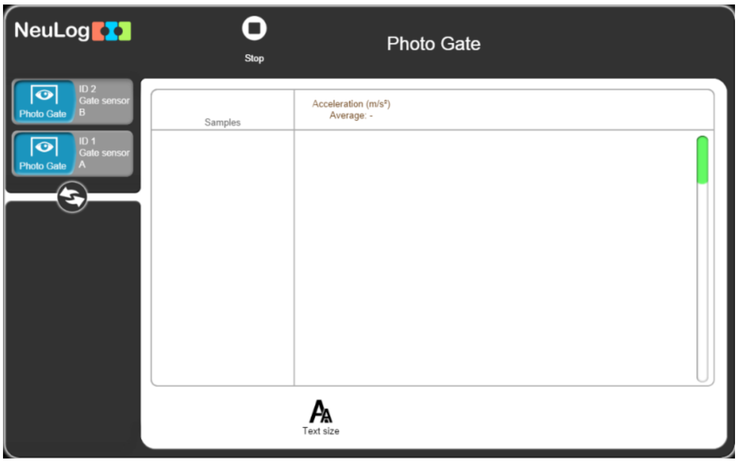
All the photo gate options are available here: **Velocity with single gate, Acceleration with single gate**, **Acceleration with two gates, Velocity with two gates**, **Delta between two gates** and **Velocity with timing card**.

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

NOTE:

When using two identical sensors, such 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 do 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 Sensor IDs if it comes up negative.

- Click on the Record icon .



- Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long the Timing card took 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 too.

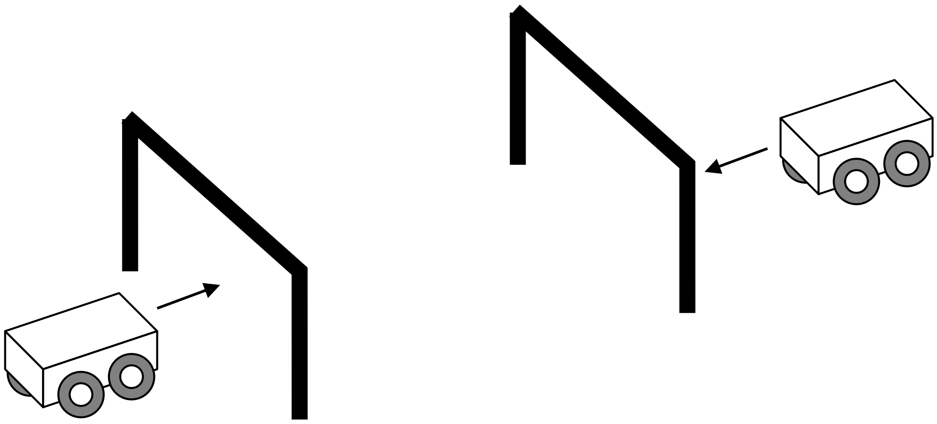
  Note that the Table also has velocities recorded as well as times.

- Click on the Stop experiment icon 

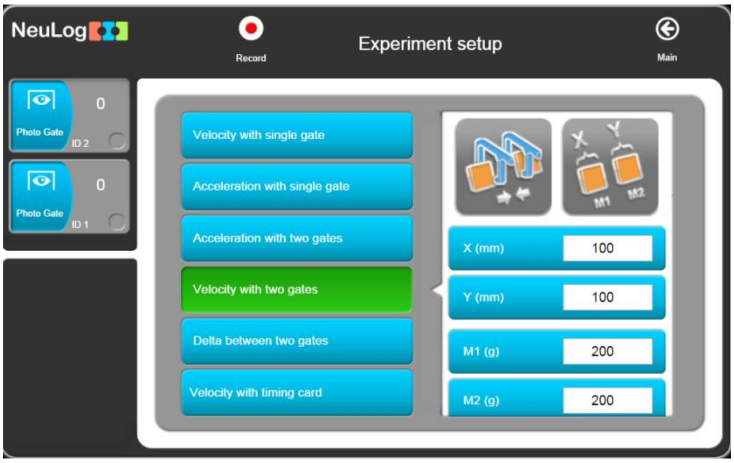
- Return to the main screen.

3.7.4 Velocity with two gates

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



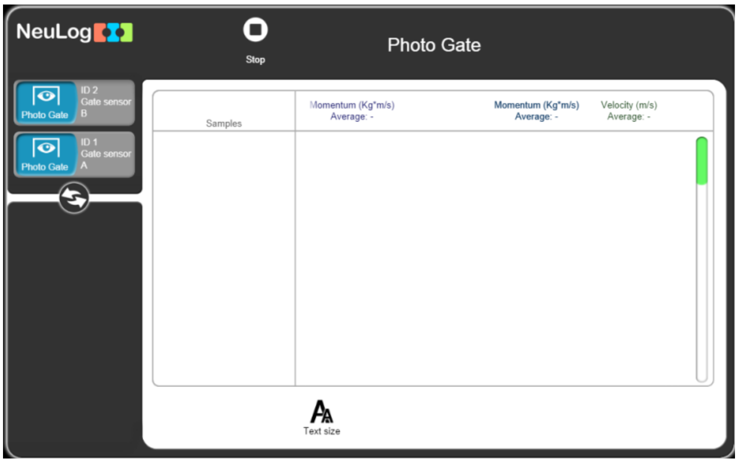
- Attach a 'flag' timing card to each cart.
- Click on the **Velocity with Two Gates** on the **Experiment Setup**.



Fields for the carts' mass are opened too.

- Write flags' width and the carts' mass in the fields.

- Click on the Record icon .



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

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

- Click on the Stop experiment icon 

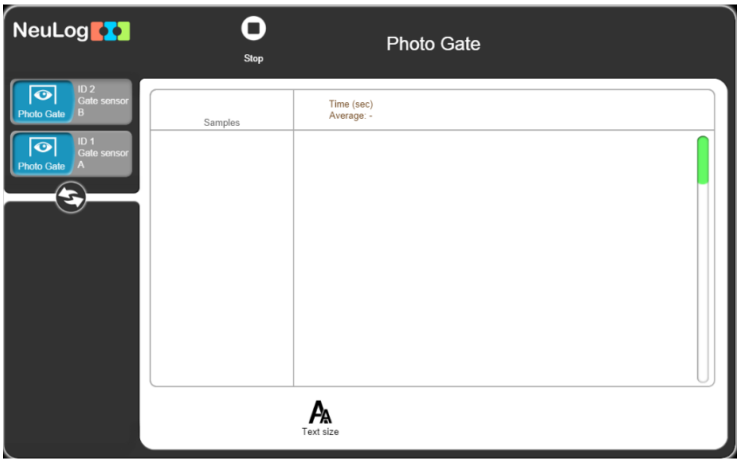
- Return to the main screen.

3.7.5 Delta with two gates

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

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

- Click on the Record icon .



- Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long the Timing card took 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 too.

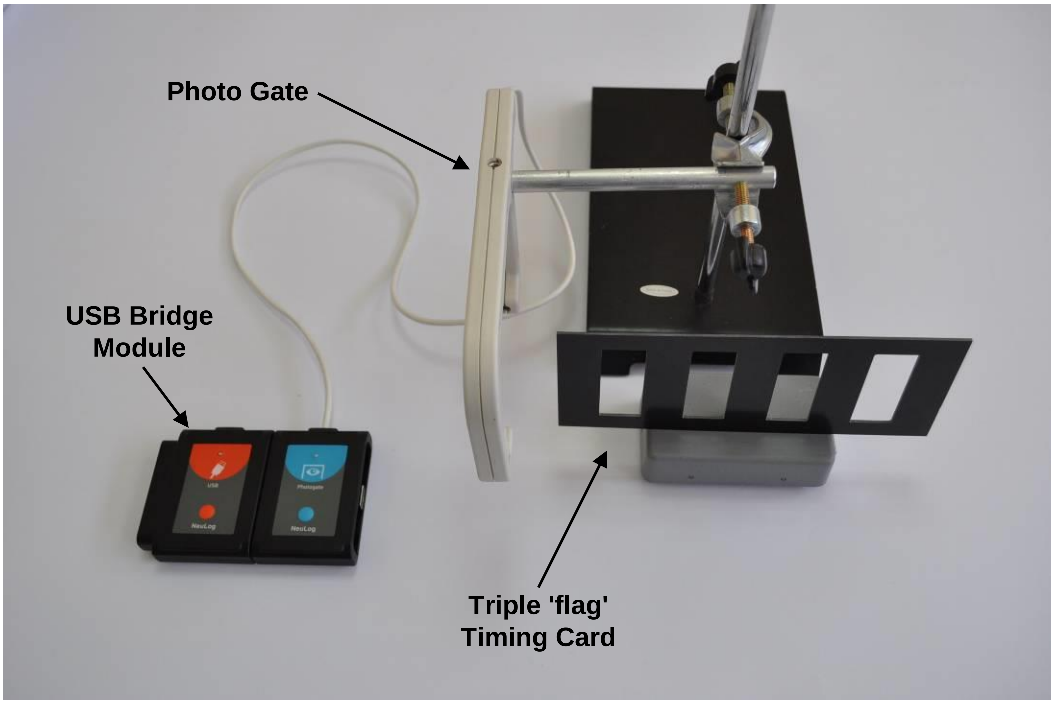
  Note that the Table also has velocities recorded as well as times.

- Click on the Stop experiment icon 

- Return to the main screen.

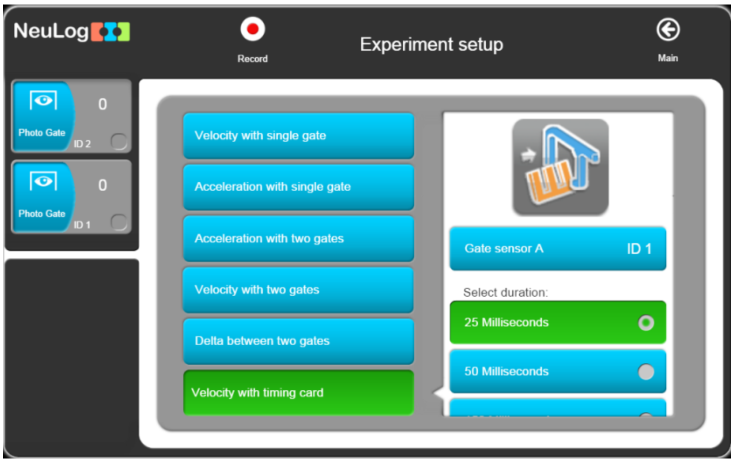
3.7.6 Velocities with timing card

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 in the previous page.

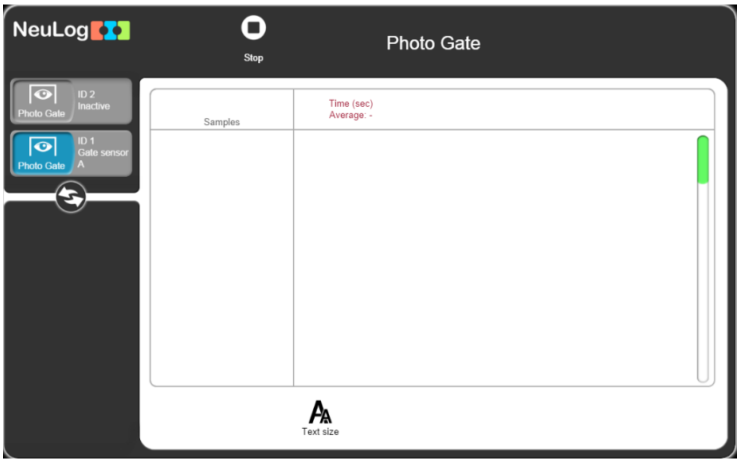
- Although for this experiment we need only one photo gate, both gates can be connected to the USB module. You just have to determine which one of them is used.
- Attach a Triple 'flag' timing card to the model car.
- Click on the **Velocities with Timing Card** on the **Experiment Setup**.



The width of the flags should be 50 mm.

- Select the experiment duration.

- Click on the Record icon .



- Pass 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 experiment icon 

- Return to the main screen.

- Disconnect the **photo gate**  from the **USB Bridge module**  but leave the **USB Bridge 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 where the sensors have been programmed by connection to the 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) or NeuLog viewer.

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.

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=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 could **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.

Starting is enabled by clicking the **Record icon**  (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.

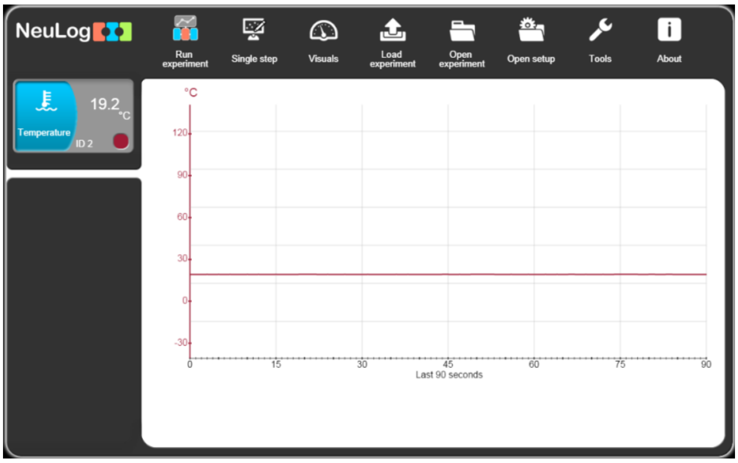
Stop the experiment by clicking on the **Stop Experiment icon**  on the PC, by pressing the **Start/Stop** buttons on the sensors, or wait for the experiment duration to be completed, so the experiment ends automatically.

Data is then uploaded in order to display and analyze it. However, all graphs would be 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 Bridge module  to a USB port on the PC.
- Connect the Temperature sensor  to the USB Bridge module .
- Enter the **NeuLog**™ main screen to display the following.



4.2 Off-line experiment with battery module

In this Off-line experiment mode you will be using sensor(s) whilst it/they are connected and powered by a **Battery module** . Each sensor can store up to 5 different experiments data.

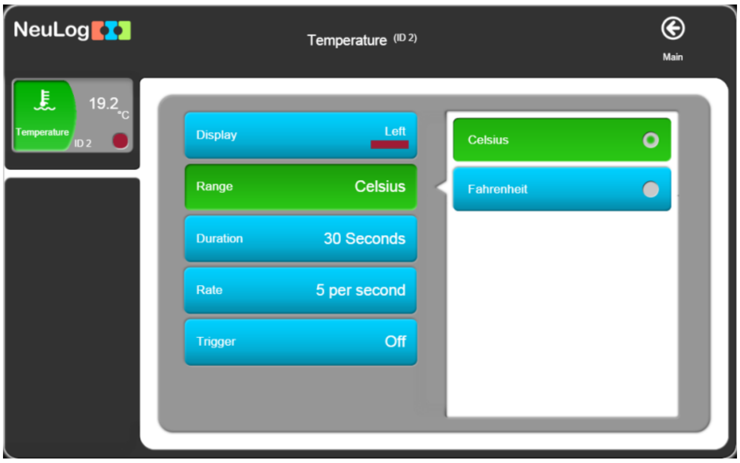
Check first that this module's battery is OK by pressing its button and seeing that the red LED alongside it lights. If the LED does not light then you will need to recharge the unit.

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

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. Check that.

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** and to '30 seconds'.
- Set the **Sampling rate** to '10 per second'.
- In this example the Trigger is **not** being used so check that the **Trigger** is **OFF**.
- Press **Back** to the **Main** screen.
- Now disconnect the **Temperature sensor**  from the **USB Bridge module**  and plug it into the **Battery module**  .
- If you have a digital display module (VIEW-101), you can connect it to the chain.

4.2.2 Running a single sensor without a trigger

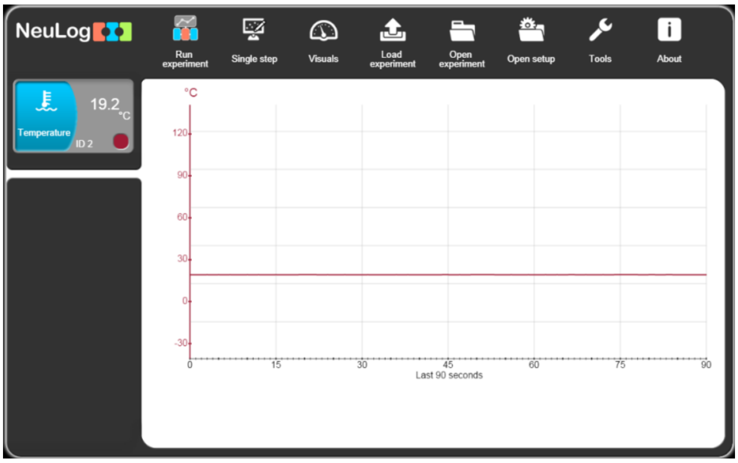
NOTE:

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

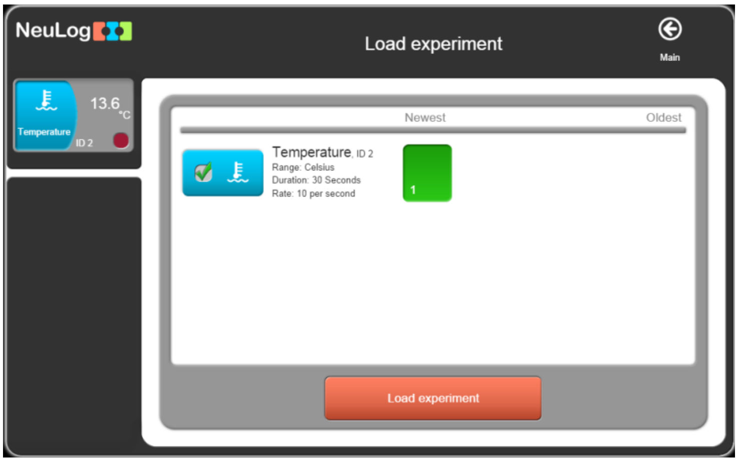
- Pour about 200ml of hot water at about 60°C into a 250ml beaker.
- Pour about 200ml of cold water at a temperature below that of the laboratory/room into another 250ml beaker.
- Press the **Start/Stop** button on the Temperature sensor. Its red light emitting diode (LED) will blink according to the sampling rate. The sensor will have started sampling the temperature 10 times per second for 30 seconds and is recording the data in its internal memory.
- After about 5 seconds insert the Temperature sensor rod into hot water.
- After about a further 10 seconds take the Temperature sensor rod out of the hot water and insert it into the cold water.

After 30 seconds, the red LED will turn **OFF**. The datalogging is complete. Pressing the **Start/Stop** button sooner would have also stopped the datalogging.

- Remove the Temperature sensor from the cold water.
- Unplug the **Temperature sensor**  from the **Battery module**  and reconnect it to the **USB Bridge module** .
- Check that you have the following screen.



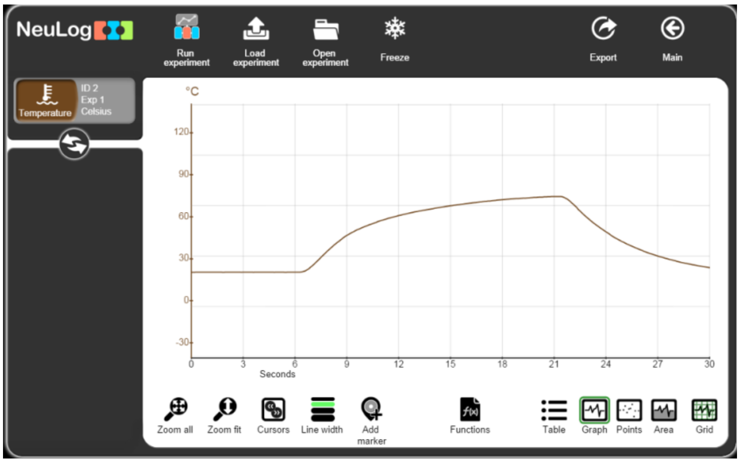
- Click on the **Load Experiment** icon  and note the following screen:



Clicking on Experiments will show the list of stored experiments in the sensor's memory (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 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.

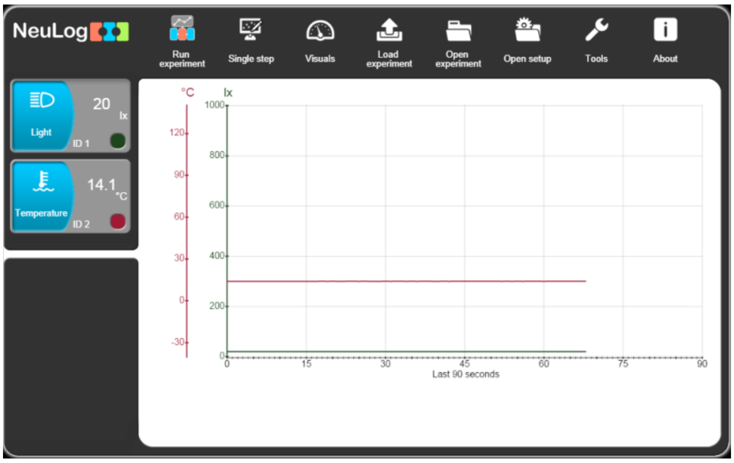
You can upload an experiment, freeze it and upload another one.

- Press **Back** to the **Main** screen.

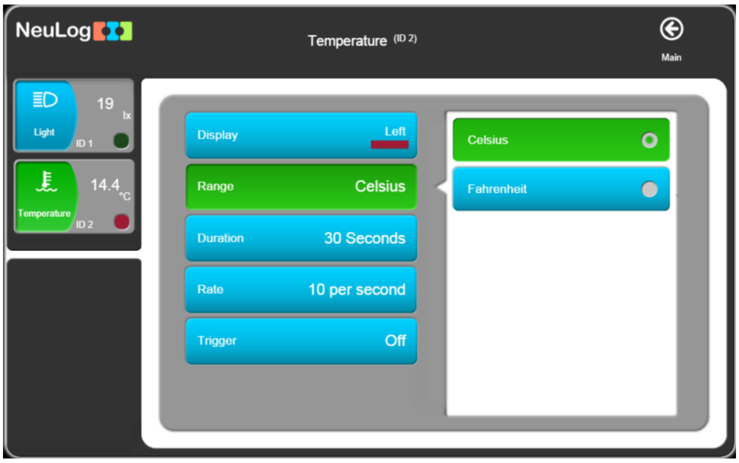
- Leave the **Temperature sensor**  and **USB Bridge module**  connected to the PC.

4.2.3 Setting up two sensors without triggers

- Additionally plug the **Light sensor**  to the **Temperature sensor**  or to the **USB Bridge module** .
- Go **Back** to the main screen and Get 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** and to '2 minutes'.
- Set the **Sampling rate** to '5 per second'.
- Check that the **Trigger** button is **OFF**.
- Press **Back**.
- Click on the Light Sensor Module box to display the Light1 – Options tab window shown below.

- Set the **Experiment duration** and to '1 minute'.
- Set the **Sampling rate** to '5 per second'.
- Check that the **Trigger** button is **OFF**.
- Press **Back**.
- Disconnect the two sensors from the **USB Bridge module**  and connect them to the **Battery module** .

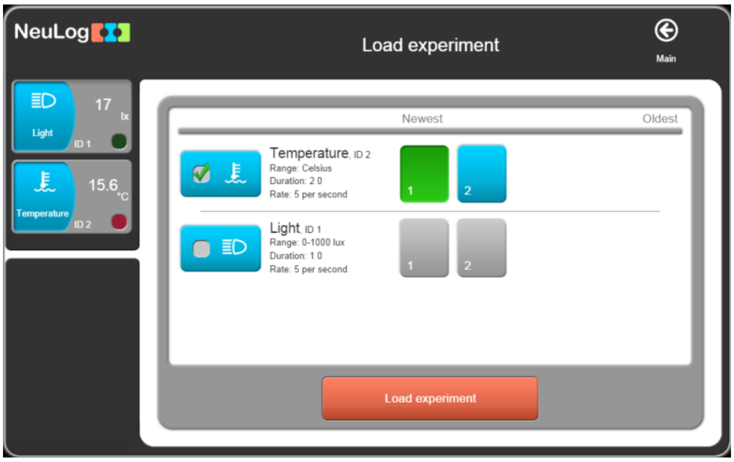
4.2.4 Running two sensors without triggers

<u>**NOTE:**</u>

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

- If not already available, pour about 200ml of hot water at about 60°C into a 250ml 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 Bridge module** .

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



The program aloud to load each of them but not both of them at a time, because the duration of the experiments in the two sensors is different

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

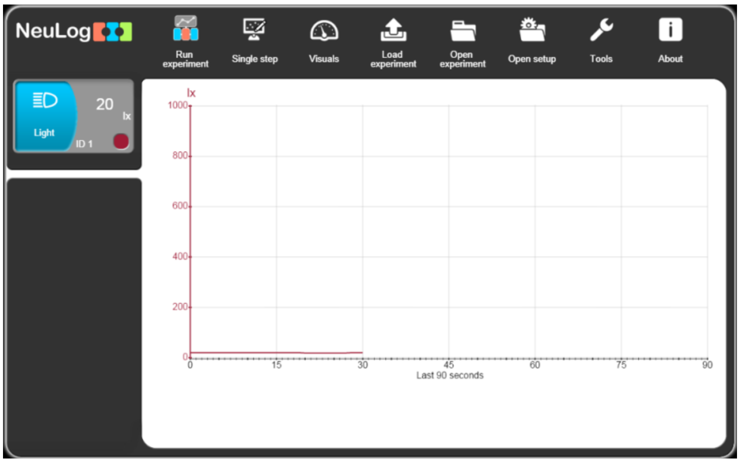
- Disconnect the **Temperature sensor** from the chain but leave the **Light sensor** and **USB Bridge module** still connected to the PC.

NOTE:

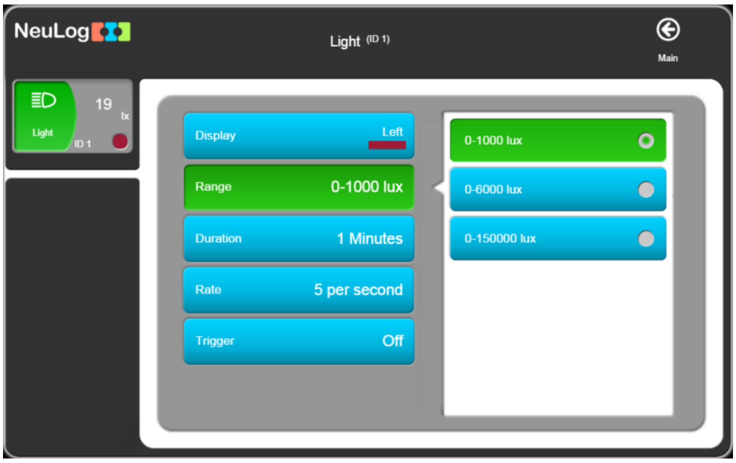
The two sensors could also have been programmed and operated separately from each other. Uploading their data subsequently could then have been done (i) separately, in which case only that sensor's data would be displayed on a graph or (ii) both together, in which case both sets of data could be overlaid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



- Click on the Light Sensor Module box to display the Light1 – 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 Light.
- Check that the **Mode** indicates 'Rise'.

- Enter the **Trigger Value** '5'.

  The button of the trigger value is changed to orange, this mean that you should send the new value to the sensor. When finished writing, click on the button and its color will change to blue to indicate that the value was transferred to the sensor.

- Disconnect the Light sensor from the **USB Bridge 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.

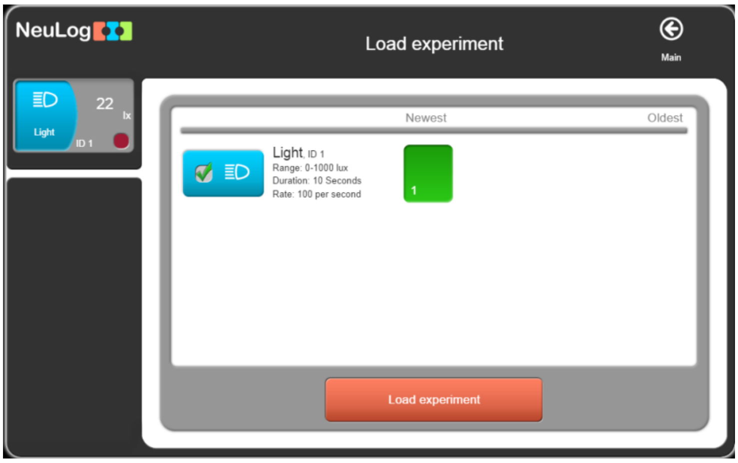
  The light sensor LED will blink fast twice with a distance between every two pulses. This means 'Waiting for trigger'.

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

  The blinking will stop.

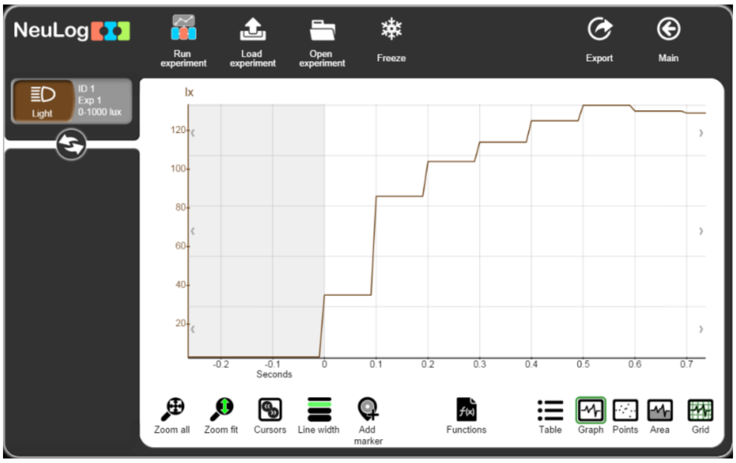
- Disconnect the **Light sensor** from the **Battery module** and reconnect it to the **USB Bridge module**.

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



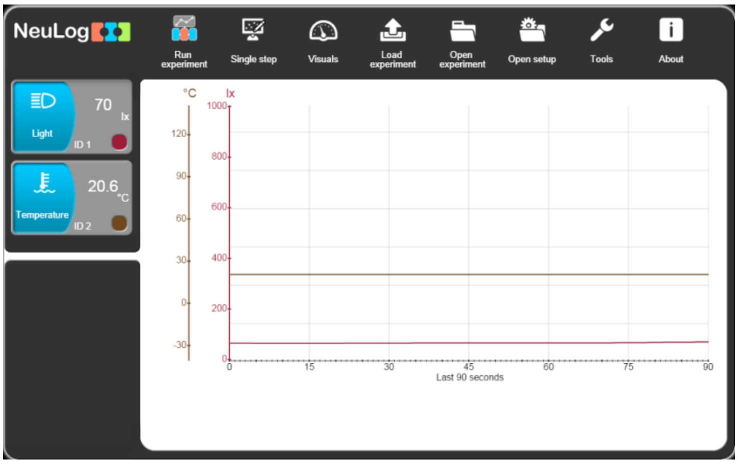
- Click on **Newest**, on the window, to upload the last stored experiment data for both sensors and then click on the **Load Experiment** button.

- Observe the graph and the pre-trigger area too.

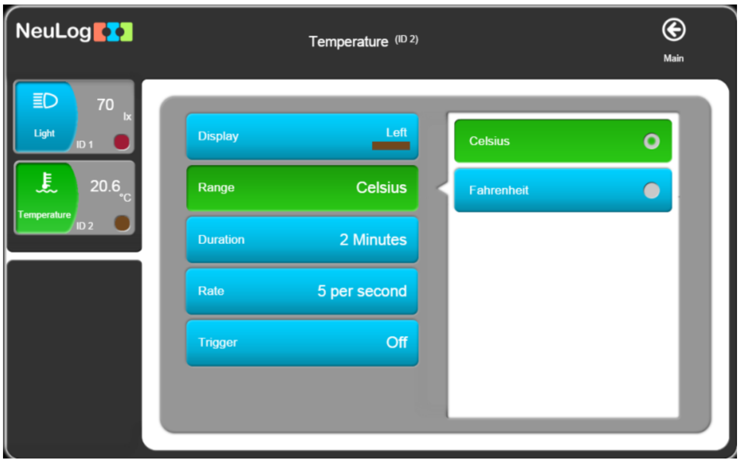


4.2.7 Setting up two sensors with triggers

- Connect a **Temperature sensor**  to the **Light sensor**  or to the **USB Bridge module** .
- Go **Back** to the main screen and and Get the following screen.

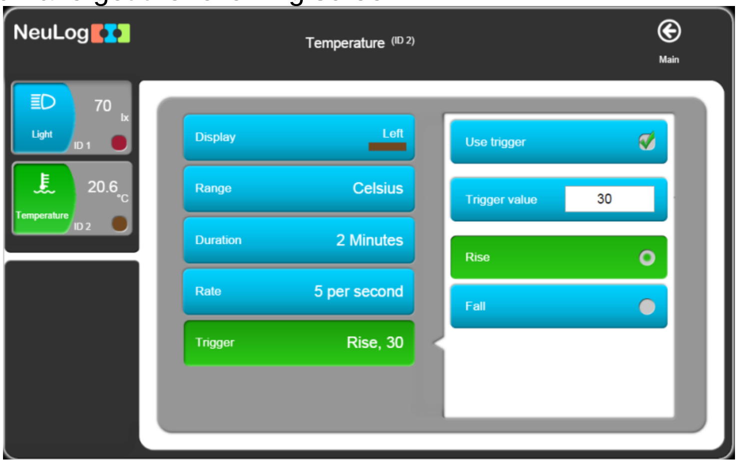


- Click on the Temperature Sensor Module box to display the Temperature Options window shown below.



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

- Check that you have got the following screen.



- Click on the Light Sensor Module box to display the Light1 Options 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'.
- Set the **Trigger** to '5' and **Rise**.
- Check that you have got the following screen.

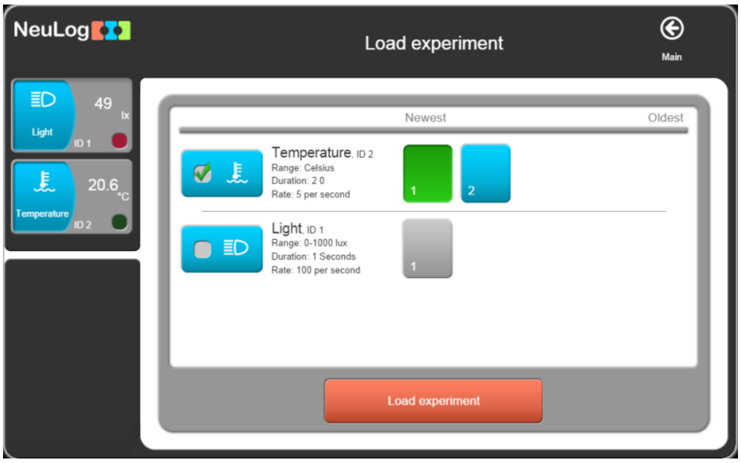
- Press **Back**.
- Disconnect the **Temperature sensor**  and **Light sensor**  from the **USB Bridge module**  and connect them to a **Battery module** .

4.2.8 Running two sensors with triggers

NOTE:

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

- If not already available, pour about 200ml of hot water at about 60°C into a 250ml beaker.
- Also pour about 200ml of cold water into another 250ml 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 Bridge module  .
- Click on the **Load Experiment** icon  and note the following screen:



The program aloud to load each of them but not both of them at a time, because the duration of the experiments in the two sensors is different,

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

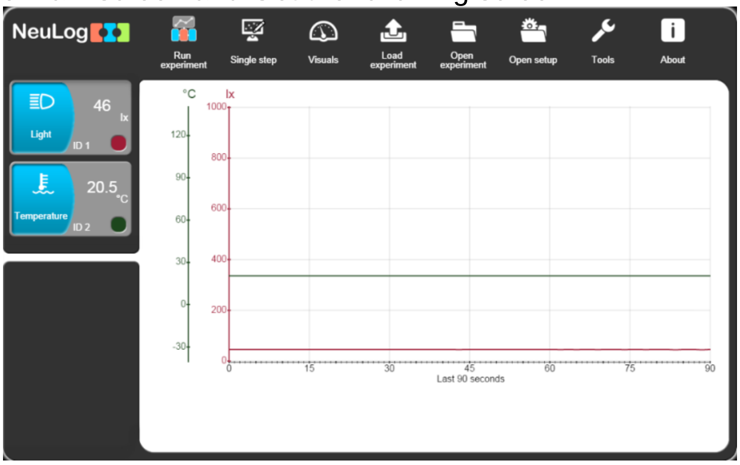
4.3 Off-line experiment mode with a PC

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.

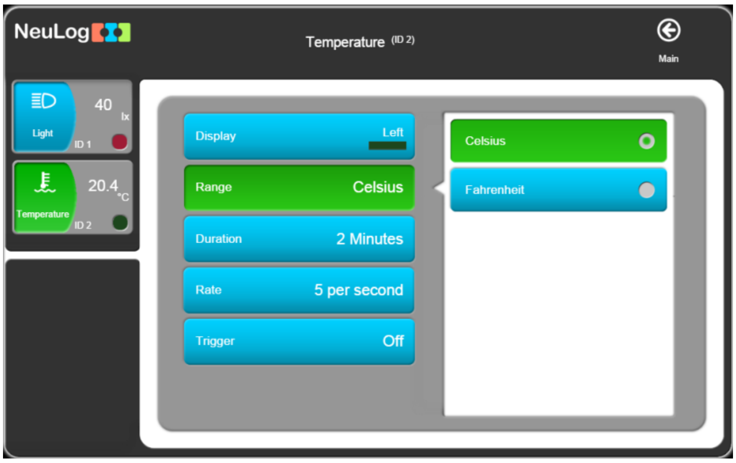
This experiment can be done with any type of MDU.

4.3.1 Setting up two sensors without triggers

- Plug the Temperature sensor  and the Light sensor  to the USB Bridge module .
- Go **Back** to the main screen and Get 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** and 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 Light1 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**.
- Press **Back**.

Both the Temperature and Light sensors have now been setup.

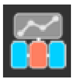
NOTE:

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

4.3.2 Running two sensors without triggers

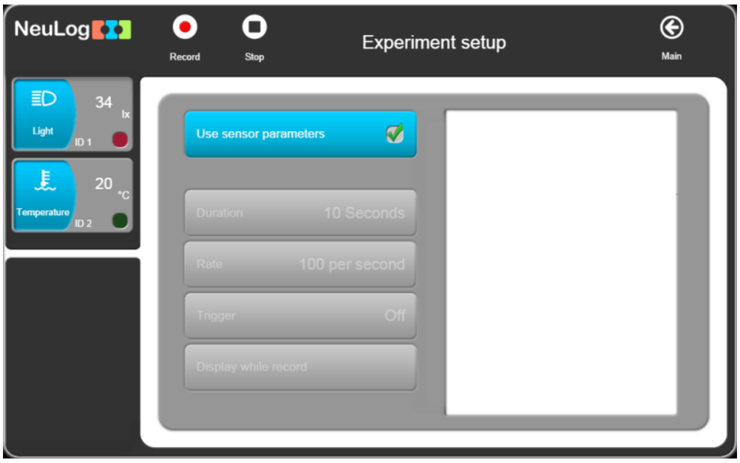
NOTE:

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

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

  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 and the two sensors will start sampling at the same time but with different experiment parameters.

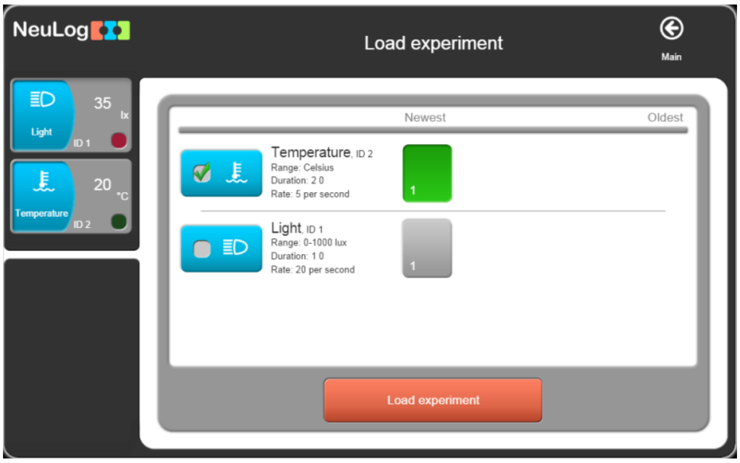
- Direct the light sensor to a light source and the ground alternately.

  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** icon and note the following screen:



The program aloud to load each of them but not both of them at a time, because the duration of the experiments in the two sensors is different,

- 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 Bridge 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 Bridge module's with the latter plugged into a PC. Communication is then as if the sensor(s) were connected directly.

The PC can be any kind of PC (Windows, MAC, and Linux).
The tablets are connected to wirelessly through WiFi to the sensors.

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

How to setup the RF module ID number is explained in section 7.2.

Notes:

<u>Only two</u> RF modules with the same ID number should be used in a classroom.

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

5.2 RF with a PC and groups of sensors

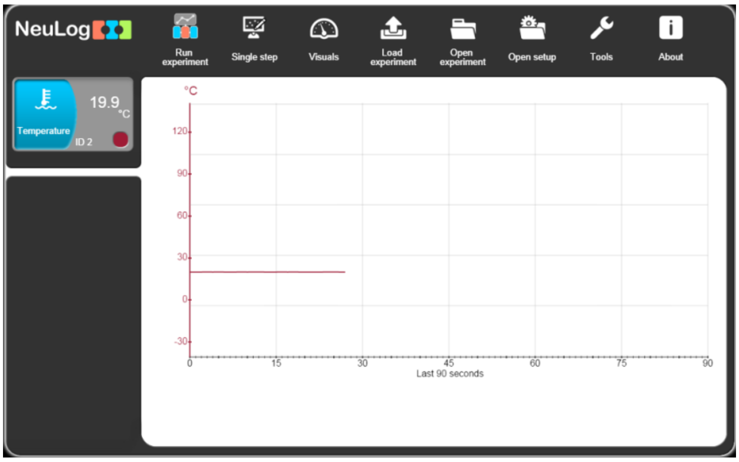
We can use one PC with up to nine groups of sensors operated as described in section 5.1.

Each group of sensors and battery module has a RF module with a different ID number connected to them.

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

Chapter 6 – NeuLog™ Tools

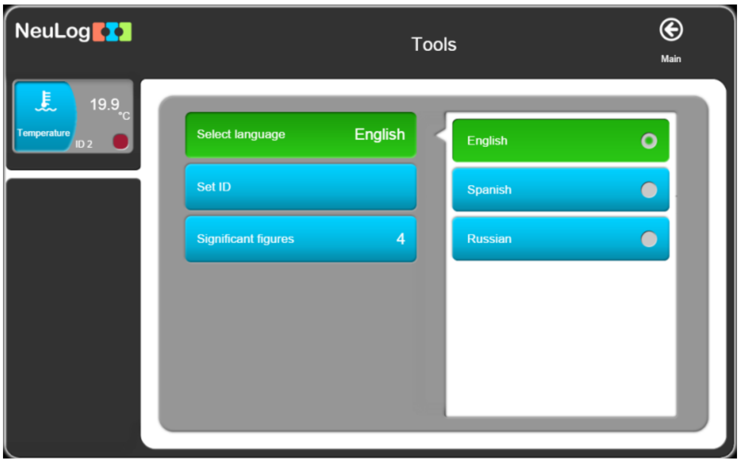
- Connect the USB Bridge module  to a USB port on the PC.
- Connect the Temperature sensor  to the USB Bridge module .
- Double-click on the **shortcut icon**  to display the following.



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. For each experiment setup an instruction document can be prepared. When the document is opened (doc, docx, wps, odt, tmd, rtf, pdf etc.) the experiment setup is automatically loaded.

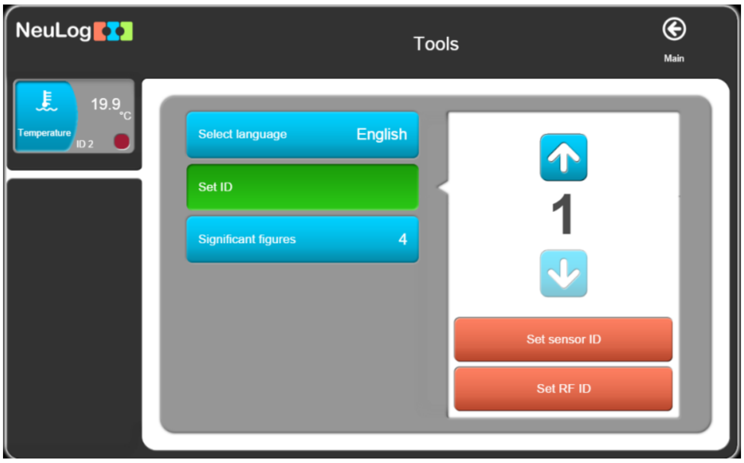
- Pressing on the NeuLog Tools button displays the following keys:



The **Language Select** key 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 that are connected to the system according to the key pressed (1 to 9). After pressing 1 to 9, an automatic search will be started.



- 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.

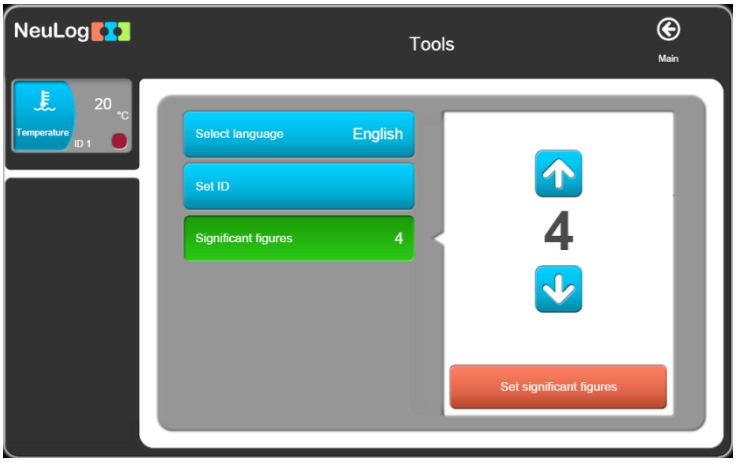
- Connect one RF module to the USB module and check that no other RF module is connected to a battery module.

- Set the **number 2** and click on the **Set RF ID**. The **Set RF ID** key permits modifying the ID of the RF module that is connected to the system according to the key pressed (1 to 9).

- Repeat the above steps and change another RF module ID to '2'.

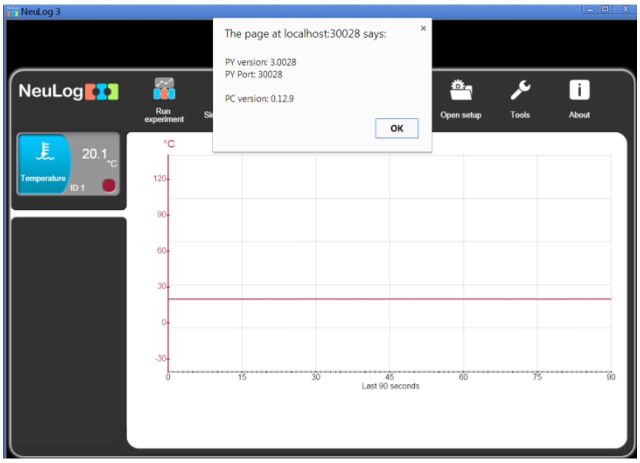
6.2 Significant figures

- The **Significant Figures** key 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 About NeuLog

The **About NeuLog** key displays the version of the software modules. 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 Voltage logger sensor NUL-201

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 ±20V maximum**).

Experiment Duration: 50 milliseconds to 31 days.

Specifications:

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
±20 V	12 bit	1%	0.01 V	3000

7.2 Current logger sensor NUL-202

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)
±2500 mA	13 bit	1%	10 mA	3000

7.3 Temperature logger sensor NUL-203

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	

7.4 Light logger sensor NUL-204

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 in 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	

7.5 Oxygen logger sensor NUL-205

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, dissemble, rinse in de-ionized water and store dry.

Sensor offset:

Offset of the probe is simply achieved in open air, taking this as a standard level of 20.9%[1]. First connect the sensor to a voltage source (the USB Bridge 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. Then click on the **Calibration 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:

Body diameter:	12 mm
Overall length:	150 mm
Cap:	16 mm OD ±30 mm Long
Construction:	Polarographic (Clark Type) design with Silver Anode/Gold Cathode, Delrin body and PTFE membrane
Range/Output:	▪ 0-20 ppm Dissolved Oxygen (0-200% saturation) ▪ Output: 0-40 mA / 0-400 mA
Response time:	98% of full response in 60 seconds at 25 °C

[1] This is an assumed stable level in the Earth's atmosphere at sea-level.

7.6 pH logger sensor NUL-206

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 offset:

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 Bridge.

First click on the pH sensor's Module box to open its Module setup window. Then click on the **Offset 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:

Body diameter:	12mm
Overall length:	150mm
Cap:	16mm OD ±30mm Long
Construction:	Epoxy Body, Round Bulb ASG VIII pH Glass, Sealed, Gel-filled Single-Junction Reference with fiber frit, Ag/AgCl wire, ATC
Range/Output:	▪ 0-14 pH ▪ mV output with isopotential point at 0±20mV at pH 7
Response time:	98% of full response in 30 seconds at 25 °C

7.7 Relative humidity logger sensor NUL-207

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

7.8 Heart rate & pulse logger sensor NUL-208

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, 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 (BPM stands for beats per minute):

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.

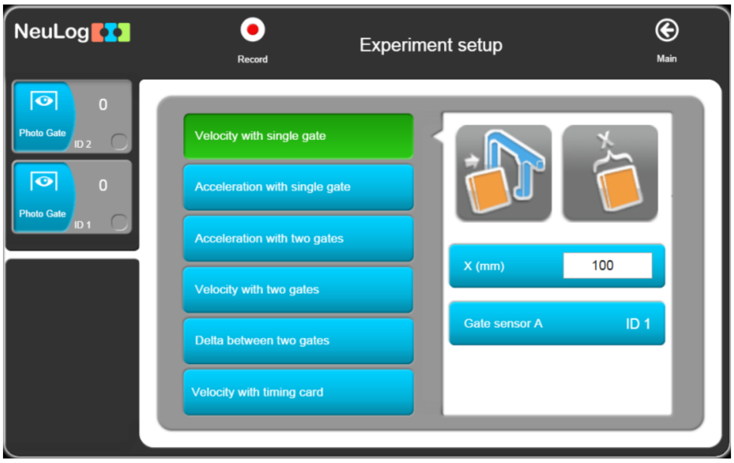
7.9 Photo gate logger sensor NUL-209

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.

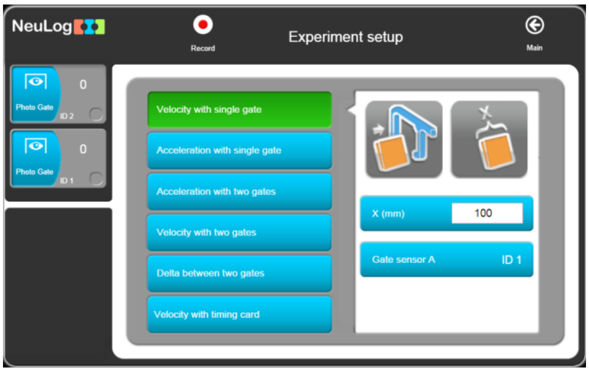
The modes of operation are selected by clicking on the relevant picture.

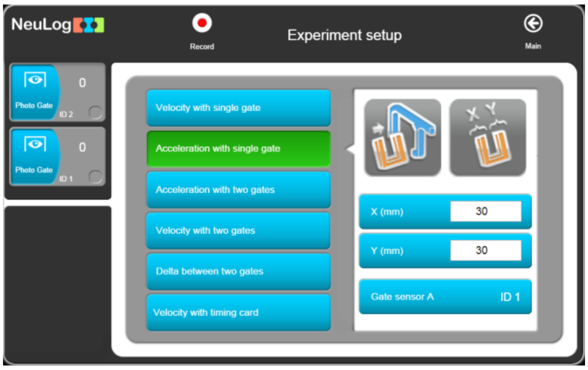
The photo gate sensor will work only On-Line and in a manner different from all the other sensors. When this sensor is connected, the system will relate only to other photo sensors that are connected and disregards all other sensors.

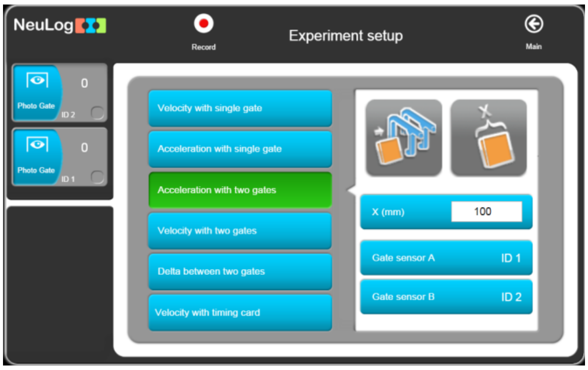
The photo gate sensor has six operating modes that are described in the following screen:

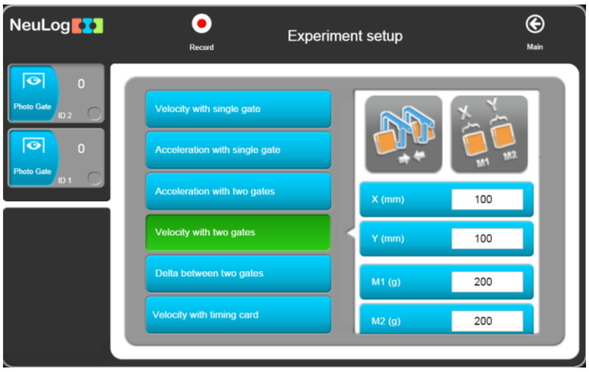


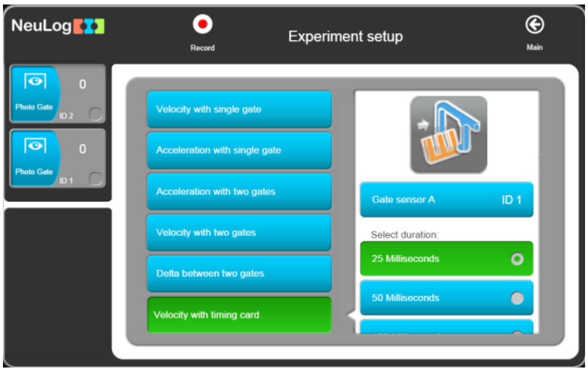
Upon selecting one of the modes of operation, one of the following windows that relate to the specific operating mode will be displayed.



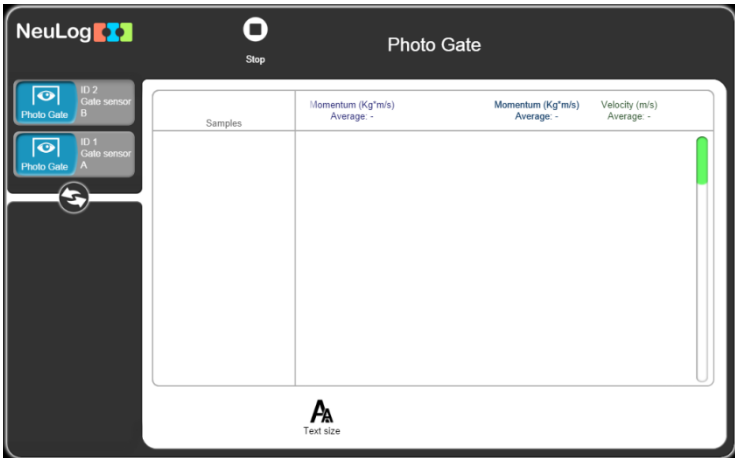








After entering the parameters and press the "Run Experiment" button, every movement of a body that is detected by one or two sensors (according to the operating mode) will display the measured data in a table. There is no graphic display for these modes of operation.



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 µS	100 µS	10,000
Double timing card with one photo gate				
Single timing card with two photo gates				
Digital status one photo gate				

7.10 Pressure logger sensor NUL-210

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	±1% $20^{o}C$-$30^{o}C$	0.01 atm	100
0 to 100 p.s.i.			0.1 p.s.i.	
0 to 700 kPa			0.1 kPa	
0 to 7 bar			0.01 bar	

7.11 Force logger sensor NUL-211

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 zeroing

Connect the sensor to a voltage source (NeuLog's Bridge, Monitor Display Unit or Battery Unit). To zero 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. Then click on the **Calibration button**.

Specifications:

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

7.12 Sound logger sensor NUL-212

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:

<table>
<tr><th>Range and operation modes</th><th>ADC resolution</th><th>Accuracy</th><th>Resolution</th><th>Max Sample Rate (S/sec)</th></tr>
<tr><td>Level: 40 to 110 dB</td><td rowspan="2">12 bit</td><td>±2 dB</td><td>0.1 dB</td><td>100</td></tr>
<tr><td>Signal: 0 to 1024</td><td>1</td><td>1</td><td>10,000</td></tr>
</table>

7.13 Motion logger sensor NUL-213

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^2

Experiment Duration: 1 second to 31 days.

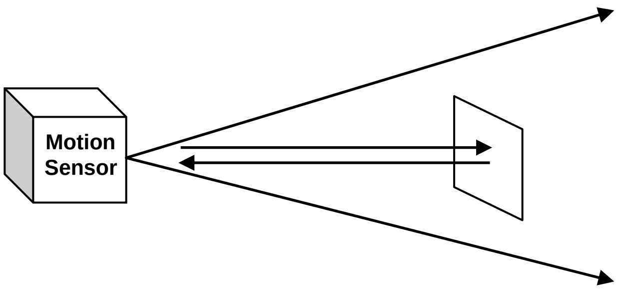
<u>Specifications:</u>

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

<u>Note:</u>

The measurement is based on ultrasonic waves, a sound wave humans 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.



7.14 Magnetic logger sensor NUL-214

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.

<u>Specifications:</u>

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

7.15 Conductivity logger sensor NUL-215

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: **µs/cm – micro Siemens per centimeter**
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 20000 µs/cm		0 to 2000 µs/cm – 0.1 µs/cm Over 2000 – 1 µs/cm	
0 to 18000 mg/L	15 bit	0 to 1000 mg/L – 0.1 mg/L Over 1000 – 1 mg/L	100
0 to 18000 ppm		0 to 1000 ppm – 0.1 ppm Over 1000 – 1 ppm	

7.16 Spirometer logger sensor NUL-216

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 area 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)
±10 L/s	14 bit	0.2 L/s	100

Note:

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.

7.17 GSR logger sensor NUL-217

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, µS

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 0 to 10 µS	16 bit	1 10 nS	100

Note:

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.

7.18 Electrocardiogram logger sensor NUL-218

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

7.19 Colorimeter logger sensor NUL-219

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 0 to 4 absorbance	14 bit	0.01 % 0.01 abs	100

Note:

The colorimeter comes with three cuvettes.

7.20 CO_2 logger sensor NUL-220

This logger sensor is based on an electromechanical reaction between CO_2 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_2 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 10,000 ppm	14 bit	1 ppm	100

Note:

The sensor must be offset before every use according to the following simple procedure:

Connect the sensor to the PC through a USB module or to a battery module.

Wait for thirty minutes to warm the sensor and press the pushbutton switch on the CO_2 logger sensor for 3 seconds.

7.21 Barometer logger sensor NUL-221

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

This sensor has five common ranges for displaying atmospheric pressure:

Ranges: **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 to106 KPa 0. 8 to1.00 Atm 23.62 to 31.30 in Hg –382 to 1950 m 600 to 795 mm Hg	15 bit	0.1 KPa 0.01 Atm 0.01 in Hg 0.1 m 0.7 mm Hg	100

7.22 Blood pressure logger sensor NUL-222

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: **mmHg – The average pressure in the air pillow in mm/Hg**
Arb – The pressure beats with no units
Arb+mmHg – 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 0 to 820 Arb 0 to 250 mm Hg + Arb	13 bit	0.24 mm Hg 0.1 mm Hg 0.24 mm Hg	100

7.23 Drop Counter logger sensor NUL-223

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 0 to 6,500 X drop vol. in ml	12 bit	1 Drop	100

7.24 Flow logger sensor NUL-224

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

7.25 Force plate logger sensor NUL-225

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

7.26 Rotary motion logger sensor NUL-226

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.

Ranges: Angle, Rad/s, Rad/s^2, Rev/s

Experiment Duration: 1 second to 31 days.

Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
$0^o$to 360^o ±345 Rad/s ±32,222 Rad/s^2 ±55 rev/s	16 bit	0.08^o 0.6 Rad/s 11 Rad/s^2 0.02 rev/s	100

Note:

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

7.27 Acceleration logger sensor NUL-227

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 to 80 m/s^2 Y axis -80 to 80 m/s^2 Z axis -80 to 80 m/s^2	10 bit	0.15 m/s^2	3000

Note:

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.

7.28 Salinity logger sensor NUL-228

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% 0 to 64,000 ppm 0 to 64,000 mg/L	16 bit	0.0064 % 64 ppm 64 mg/L	100

7.29 Soil moisture logger sensor NUL-229

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 –20 to 50 KPascal	13 bit	0.01 cBar 0.01 KPascal	100

7.30 UVB logger sensor NUL-230

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 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 1500 mW/m^2	14 bit	0.1 mW/m^2	100

7.31 Turbidity logger sensor NUL-231

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	10 bit	0.20 NTU	100

7.32 UVA logger sensor NUL-232

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 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 50,000 mW/m^2	14 bit	4 mW/m^2	100

7.33 Surface temperature logger sensor NUL-233

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 140°C –40°F to 284°F	12 bit	0.1°C 0.1°F	100

7.34 Wide range temperature logger sensor NUL-234

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 1200°C –328°F to 2200°F	15 bit	0.1°C 0.1°F	100

7.35 Infrared thermometer logger sensor NUL-235

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 –22°F to 719°F	13 bit	0.1°C 0.1°F	100

7.36 Respiration monitor belt logger sensor NUL-236

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

7.37 Hand dynamometer logger sensor NUL-237

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 0 to 112 lb_F 0 to 50 kg	13 bit	0.1 lb_F 0.02 lb_F 0.01 kg	100

7.38 Calcium logger sensor NUL-238

The NeuLog calcium sensor enables measurements of ionic calcium (Ca2+) 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 0.02 to 40,000 ppm	14 bit	0.3 mg/L (0.02 to 100 mg/L) 0.1 mg/L (100 to 1,000 mg/L) 130 mg/L (1,000 to 40,000 mg/L)	100

7.39 Chloride logger sensor NUL-239

The NeuLog chloride sensor can be used to measure the concentration of chloride ions (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)
1.8to 35,000 mg/L 1.8 to 35,000 ppm	14 bit	0.1 mg/L (1.8 to 1,000 mg/L) 250 mg/L (1,000 to 35,000 mg/L)	100

7.40 Ammonium logger sensor NH_4^+ NUL-240

The NeuLog ammonium sensor can be used to measure the concentration of ammonium ions (NH4+) 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.

<u>Specifications:</u>

Range and operation modes	ADC resolution	Resolution	Max sample rate (S/sec)
0.02 to 18,000 mg/L 0.02 to 18,000 ppm	14 bit	0.03 mg/L (1.8 to 1,000 mg/L) 0.1 mg/L (100 to 1,000 mg/L) 130 mg/L (1,000 to 18,000 mg/L)	100

7.41 Nitrate logger sensor NO_3^- NUL-241

The NeuLog nitrate sensor can be used to measure the concentration of nitrate ions (NO3-) 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.

<u>Specifications:</u>

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0.1 to 14,000 mg/L	14 bit	0.1mg/L (0.1 to 1,000 mg/L) 98 mg/L (1,000 to 14,000 mg/L)	100
0.1 to 14,000 ppm as N		0.1ppm (0.1 to 1,000 ppm) 98 ppm (1,000 to 14,000 ppm)	

7.42 Anemometer logger sensor NUL-242

The NeuLog 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 0.00 to 75 mph	15 bit	0.01 km/hr 0.01 mph	100

7.43 GPS position logger sensor NUL-243

The NeuLog 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.

Position accuracy	10 m, 2D RMS 5 m, 2D RMS with WAAS enabled
Velocity accuracy	0.1 m/s
Maximum sample rate	1 Hz
Time to first fix (average)	42 s, cold start 38 s, warm start 1 s, hot start
Channels	20

7.44 Dew point logger sensor NUL-245

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 –182.0 to 228.0°F	12 bit	0.1°C 0.1°F	100

7.45 Charge logger sensor NUL-246

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	

7.46 USB bridge module USB-200

This NeuLog™ 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.

7.47 Battery module Bat-200

The Battery module supplies power to a sensor, or chain of sensors, operating in the Off-Line mode, and to sensors connected to an RF Communication module.

This module can be checked for the 'goodness' of its internal battery by pressing its pushbutton. This will turn **ON** its light emitting diode (LED) when the battery is OK

Specifications:

Internal Rechargeable Battery
Battery test button

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

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. Check that.

7.48 RF Communication module  RF-200

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: 2.4GHz DSSS (Direct-sequence spread spectrum).
Bit Rate: 1Mbps.
Maximum distance of use in open space: 30m.

7.49 Digital display module  VIEW-200

The VIEW-200 is a small display module that can be connected to any chain of logger sensors working off-line with a Battery Module.

The VIEW-200 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.

7.50 Graphic display module  VIEW-101

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 VIEW-101 can be connected to a chain of sensors ending with the battery module connected to the last sensor of the chain.

When the GDU VIEW-101 receives 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 same icons as the NeuLog^{TM} software:

 – 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.

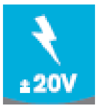
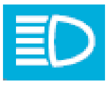
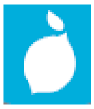
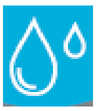
 – Tools: Set sensor ID, set RF ID, set screen shut down, turn the viewer off. The last two functions are aimed for saving battery.

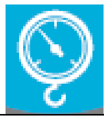
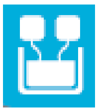
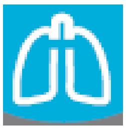
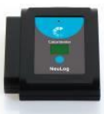
Appendix A – NeuLog^{TM} Modules

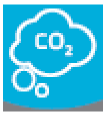
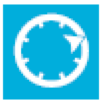
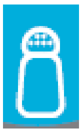
A.1 Accessory modules

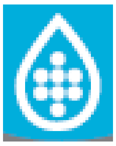
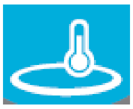
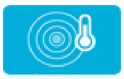
Catalog No.	Module	Module Symbol	Photographic Image	Purpose
BAT-200	Battery Module			Powers logger sensors when not connected to PC or Monitor Display Unit
RF-200	RF Communication Module			Enables wireless connection of logger sensors to PC and Monitor Display Unit
USB-200	USB Bridge Module			Connects logger sensors to PC

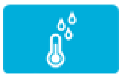
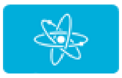
A.2 Logger sensors modules

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-201	Voltage logger sensor			Measures voltage in DC and AC circuits
NUL-202	Current logger sensor			Measures current in DC and AC circuits
NUL-203	Temperature logger sensor			Measures temperature
NUL-204	Light logger sensor			Measures level of Illumination
NUL-205	Oxygen logger sensor			Measures % oxygen in air and dissolved in water
NUL-206	pH logger sensor			Measures relative pH
NUL-207	Relative Humidity logger sensor			Measures humidity
NUL-208	Heart Rate & Pulse logger sensor			Measures pulse rate and blood flow
NUL-209	Photo/Light gate logger sensor			Measures time and, indirectly, speed/velocity and acceleration

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-210	**Pressure logger sensor**			**Measures gas or air pressure**
NUL-211	**Force logger sensor**			**Measures forces, both push and pull**
NUL-212	**Sound logger sensor**			**Measures sound level and displays waveforms**
NUL-213	**Motion logger sensor**			**Measures distance, velocity and acceleration**
NUL-214	**Magnetic logger sensor**			**Measures magnetic field intensity**
NUL-215	**Conductivity logger sensor**			**Measures solution conductivity**
NUL-216	**Spirometer logger sensor**			**Measures lung air flow and volume**
NUL-217	**GSR logger sensor**			**Measures Galvanic Skin Response**
NUL-218	**Electrocardiogram logger sensor**			**Measures electrocardiogram**
NUL-219	**Colorimeter logger sensor**			**Measures solution RGB color transfer and absorbance**

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-220	CO_2 logger sensor			Measures CO_2 in air
NUL-221	Barometer logger sensor			Measures air pressure and altitude
NUL-222	Blood pressure logger sensor			Measures blood pressure
NUL-223	Drop Counter logger sensor			Counts falling drops
NUL-224	Flow logger sensor			Measures water flow
NUL-225	Force plate logger sensor			Measures high weight
NUL-226	Rotary motion logger sensor			Measures rotary speed, acceleration and rounds
NUL-227	Acceleration logger sensor			Measures 3D acceleration
NUL-228	Salinity logger sensor			Measures salt content in a solution

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-229	Soil moisture logger sensor			Measures soil moisture
NUL-230	UVB logger sensor			Measures UVB radiation
NUL-231	Turbidity logger sensor			Measures solution turbidity
NUL-232	UVA logger sensor			Measures UVA radiation
NUL-233	Surface temperature logger sensor			Measures temperature of a surface
NUL-234	Wide range temperature logger sensor			Measures a wide range of temperature levels
NUL-235	Infrared thermometer logger sensor			Measures temperature remotely
NUL-236	Respiration monitor belt logger sensor			Measures the breathing of a subject
NUL-237	Hand dynamometer logger sensor			Measures the pressing force
NUL-238	Calcium logger sensor			Measures the concentration of ionic calcium (Ca^{2+})

NUL-239	**Chloride logger sensor**			**Measures the concentration of chloride ions (Cl^-)**
NUL-240	**Ammonium logger sensor**			**Measures the concentration of ammonium ions (NH_4^+)**
NUL-241	**Nitrate logger sensor**			**Measures the concentration of nitrate ions (NO_3^-)**
NUL-242	**Anemometer logger sensor**			**Measures the velocity of the wind**
NUL-243	**GPS position logger sensor**			**Determines latitude, longitude, altitude and horizontal velocity anywhere on Earth**
NUL-245	**Dew point logger sensor**			**Gives the temperature below which water vapor condenses into liquid water**
NUL-246	**Charge logger sensor**			**Measures electrostatic charges**

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

Appendix B – NeuLog™ Through WiFi

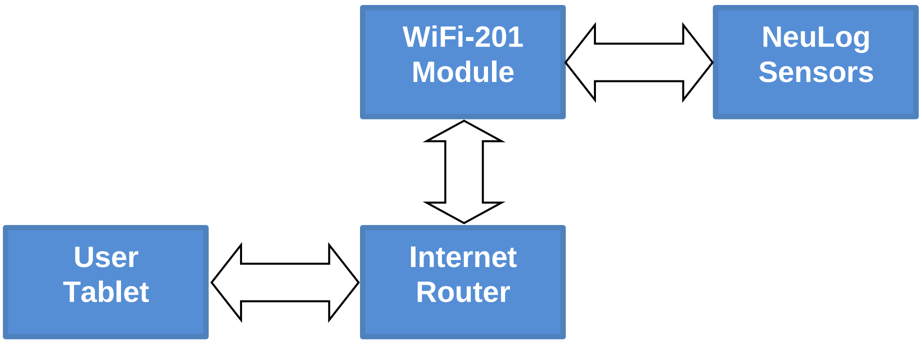
The WiFi module is without a doubt one of the most advanced and innovative elements that NeuLog has to offer. Data collection and analysis with NeuLog sensors can be performed through any device which has wireless capabilities such as iPads, Android tablets, smartphones, Windows, Mac, and Linux based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

There is no downloaded application or software installation as they are built directly into the WiFi module which transmits its own closed wireless network. This means that you do not need your own wireless network – though if you have one, a simple setting can be changed on the WiFi module to allow surfing of the web at the same time!

The WiFi module has three operating modes:

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

2. Use **Client Mode** in places that have wireless Internet communications. The Tablet will communicate with the WiFi 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 USB module connected directly to a PC or MAC.

B.1 Using the NeuLog WiFi module

The NeuLog WiFi module is a very advanced piece of equipment; having capability to transmit its own wireless network as well record data from up to 5 NeuLog sensors at a time.

The NeuLog WiFi module can be powered by NeuLog battery module or by USB power source.

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

You'll notice that on the front of the WiFi-201 module there are four LED lights labeled A, C, T, and U.

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

C: (green LED) When the green LED is the only light on, the WiFi module is in Client Mode (described below) and allows your wireless devices to control sensors through the website www.Wifi201.com as well as browse the internet.

T: (red LED) The red LED will blink when there is active communication between any connected sensors and the NeuLog software.

U: (yellow LED) The yellow LED will remain lit when the WiFi 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 WiFi module three times.

Control and view modes:

When multiple users are connected to the WiFi module's network; one user at a time can enter "control mode" the others users will be defaulted to "view mode".

Control mode – Entering control mode allows that 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 once.

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 WiFi module's network; they automatically begin in "view mode". In view mode; users have almost full access to the software – only lacking the ability to manipulate data and start/stop experiments. 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 WiFi module. In the event that anyone used the WiFi module as the controller and forgot to disconnect from it, the WiFi module will not allow any other user to connect to the WiFi module as a controller.

In order to allow another controller to access the WiFi module, press and hold the push button located on the front panel of the WiFi 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 NeuLog WiFi 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. Because the network is closed; you will not be able to browse the internet, if you wish to browse the internet while using the WiFi module please locate the "Client mode" procedural guide in this manual beginning on page 5.

1. Connect up to 5 NeuLog sensors directly to the left side of the WiFi-201 module (no wires required).

2. Connect either a BAT-200 or a USB to micro USB cable to the WiFi-201 unit to supply power.

3. For further WiFi-201 instructions or the WiFi-201 quick start guide please visit http://neulog.com/SoftwareandApplication.php.

4. The WiFi-201 indicator lights will flash; take no action until the LED to the far left turns blue.

5. Take your tablet or smart phone and go to the Wi-Fi settings and select the NeuLog network which matches the WiFi module ID found on the back of the WiFi-201 device. (**NeuLog1334** for example)

6. Give your device 1-2 minutes to connect to the WiFi-201 network.

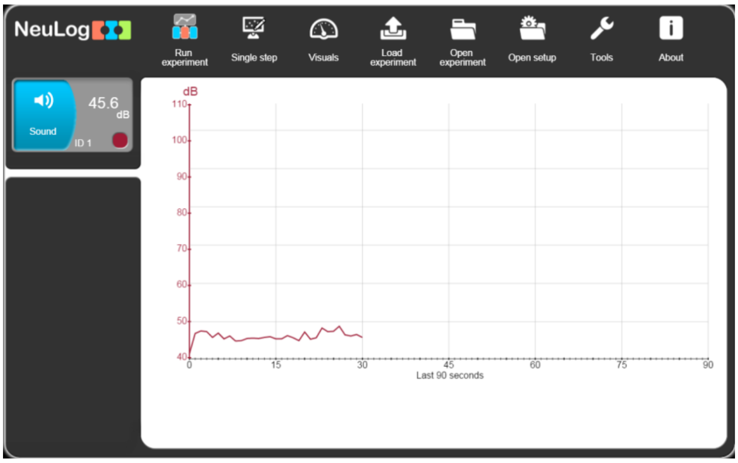
7. Once the device is connected go to your browser and type in the website **wifi201.com** into the URL bar, then wait for 30-60 seconds.

Note:

There 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” but switching between them is both possible and very easy. Control mode allows the user to change experimental parameters and both start and stop data collection. View mode allows the user to view the data being recorded.

8. If you are the first one to connect to the WiFi module you will get the "Control Mode".



9. 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.

10. To set the sensors’ settings click on each sensor’s icon.

11. To run an experiment and collect data click “Run experiment”.

B.3 Client mode use

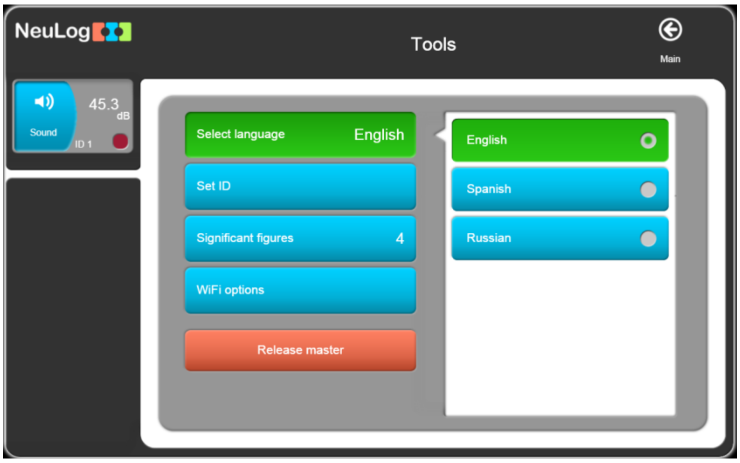
If you have a wireless network and wish to browse the internet while using the NeuLog WiFi module; you can use client mode to connect the WiFi module to your local internet. By default the WiFi module starts in “Access point mode” but can easily be changed to “Client mode”.

Note:

Before following this procedural guide you must configure your WiFi module using the “Access point mode” guide above. Access point mode is most commonly used.

1. Configure your WiFi 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 NeuLog WiFi module directly to your local wireless network allowing you to browse the internet.

Note:

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

6. If 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 WiFi module will remain on.

7. At this point you must connect to your local wireless connection (the information you put into the "Client Mode" boxes).

8. On the new screen you get, click the **Connect** button to reconnect the bowser to the wifi201 module

9. You will now be in client mode with the ability to browse the internet using your smart device.

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 WiFi module.

11. Click "Connect" and now you will be able to access the NeuLog software broadcast from the WiFi module.

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

Important comment:

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

In order to allow another controller to access the WiFi module, press on the push button on the WiFi module panel continuously for about 3 seconds until all 3 lights ate lit and then release the push button.

B.4 Using the WiFi-201 in USB mode

USB mode allows you to use your WiFi module as if it were a NeuLog USB-200. This requires a computer which has the NeuLog software (available as a free download on www.NeuLog.com.

By connecting the WiFi module to your sensors and computer via the included USB to micro USB cable, you are able to stream data directly from your sensors to the NeuLog software.

To enter USB Mode:

1. Download and install the NeuLog software (www.NeuLog.com/SoftwareandApplication.php) onto the computer which you plan on using.

2. Connect the WiFi module to the computer with the NeuLog software using the included USB to micro USB cable, you'll see the LED lights blink for a moment while the module powers on.

3. Connect your NeuLog sensors to the side of the WiFi module, the red LED on each sensor should blink to acknowledge they are working properly.

4. Press the button located on the front panel of the WiFi module three times, the yellow LED labeled 'U' 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 Access Point mode from USB mode, press the button on the WiFi module faceplate three times again.

B.5 Troubleshooting walkthrough

Due to the technological complexity of the NeuLog WiFi-201 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 NeuLog WiFi module can easily be cleared and updated!

If you are noticing that the performance of your NeuLog WIFI-201 module is acting sporadic please follow the guides below:

Restarting the WiFi module

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

1. Connect the WiFi module to a power source – this can be either a charged BAT-200 or directly to your computer using the USB to micro USB cable.

2. The LED lights on the WiFi 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 WiFi module is powered, simply press and hold the button on the front panel of the WiFi module for roughly 4 seconds (until the green, red, and blue 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 WiFi module is still sporadic please continue to the Updating the WiFi module's firmware walkthrough below.

B.6 Updating your WiFi module's firmware

If restarting your NeuLog WiFi module didn't solve the WiFi module's performance issues, please update your WiFi module firmware as per the guide below.

Firmware updates for the NeuLog WiFi module are regularly released to the NeuLog website (http://neulog.com/UpgradeFirmware.php) and it is recommended to check back often for the latest releases. Note: A full WiFi firmware update walkthrough is also available on the website listed above.

Materials needed:

- A computer with wireless capability running a Windows operating system
- WiFi-201 module + USB to micro USB cable

1. Download the latest NeuLog WiFi firmware update from the link above.

2. Install the NeuLog WIFI201 firmware updater.

3. Power your WIFI-201 module by connecting a charged BAT-200 or through connection to your computer using the included USB to micro USB cable.

4. After a few moments when only the blue LED light remains on – the wireless network (named NeuLogXXXX) is being transmitted.

5. Open your computers wireless connection settings and connect to the NeuLogXXXX wireless network.

   Note:

   You may get a notification that you now have a "limited" connection – this is OK as it simply means you don't have access to the internet.

6. Open the WiFi firmware updater, titled "neulog wifi201 update" (the file you downloaded and installed in step 1)

7. A small window will open, choose the option "PW2" and click "Start".

8. A command prompt window will now open. You may be prompted to enter "y/n" – if you are type "y" and press Enter.

9. The updater will run automatically and will take about two minutes.

10. When the firmware update is complete you can close the command prompt, and power cycle the WiFi module by unplugging it from your power source.

11. Your WiFi module is now up to date!

If problems with your NeuLog WIFI-201 module continue to persist, please contact NeuLog for additional assistance.