

NEULOG MOTION LOGGER SENSOR GUIDE



NeuLog motion logger sensor NUL-213

The NeuLog motion sensor can be used for any science experiment which requires accurate distance, velocity, or acceleration readings such as in the fields of Physics, Mechanics, Physiology, Biology, etc.

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

The motion sensor uses an ultrasonic transducer to both transmit an ultrasonic wave, and measure its echo return. Objects in the range of 0.25 to 6 meters can accurately be measured to give distance, velocity and acceleration readings using this method.

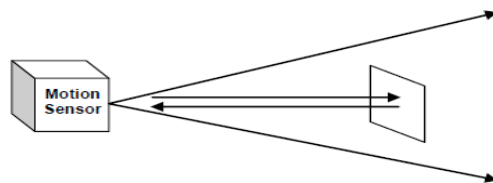
Among hundreds of possible experiments that can be performed with the NUL-213 sensor are: gravity, ball drops, momentum, impulse, conservation of energy, kinetic vs. potential energy, and many more.

The motion sensor's measurement units are:

- Meters (m): The SI distance unit
- Meters/second (m/s): The SI velocity unit which measures the distance traveled over time
- Meters/second² (m/s²): The SI acceleration unit which measures the change in velocity over time.

For best results:

The NUL-213 motion sensor has a working range between 0.25 m and 6.0 meters; results may be inconsistent outside of this range. Ultrasonic waves emitted from the sensor spread out in a cone pattern at about 15° around the point of reference.



- If possible, attach the sensor to something stable to avoid movements which can give skewed readings.
- If you get poor readings, another object in the foreground or background within the cone may be reflecting the ultrasonic waves adding noise to the experiment.
- Use objects which are at least 10 cm x 10 cm when tracking specific targets.
- For smaller targets, we recommend starting the object closer to the sensor; for larger objects we recommend starting farther away.
- When testing in areas with many hard surfaces, the waves may bounce around and create extra noise for the detector. This can cause irregular graphs. To reduce the noise level, try covering some of the surrounding surfaces with a soft material to dampen sound such as cloth or foam.
- When using the motion sensor to detect an individual's movements, try carrying the sensor instead of pointing it at oneself. For example, to measure a student's velocities have him/her walk or run with the sensor while pointing it to the wall.
- Make sure your motion sensor is not mounted near a computer, monitor or television.
- Sometimes other sources of sound (such as fans, motors, etc. can affect results).
- Try various sample rates until the cleanest data is observed, slow rates may provide better results for certain experiments.

Distance, velocity, and acceleration graphs:

During motion experiments, it is often beneficial to show distance, velocity and acceleration, all on the same graph. Using the NeuLog application it is very easy to plot all three graphs at once:

1. Follow the "Quick start procedure" section to connect the motion sensor to your chosen device.
2. Once your motion sensor has been detected, click on the "Module setup" button located in the motion sensor module box on the left side of the screen and change the range to "Distance".
3. Collect data.
4. Click the "Module setup" button again.
5. This time click on the "Speed & Acceleration" button; this will add velocity and acceleration columns to the table as well as velocity and acceleration data to the graph.

Note: The velocity and acceleration graphs have assigned colors; to view which is which you can look at the colors on top of the table columns.

NEULOG MOTION LOGGER SENSOR GUIDE



Quick start procedure:

PC or Mac Computer

Materials needed:

- NUL-213 Motion Sensor
- USB-200 USB Module
- USB to mini USB cable (included with the USB-200 module)

Your motion sensor needs to be connected to a USB-200 module. The USB-200 module then connects to a computer via a USB to mini-USB cable. Please note that you cannot plug the motion sensor directly into the computer.

The browser based application can be downloaded for free at www.NeuLog.com as well as a full application user guide. Choose "Downloads" on the main menu and then choose "Software and Application".

Procedure:

1. Install the NeuLog application.
2. Connect the USB-200 module to the PC or Mac.
3. Connect the motion sensor to the USB-200 module (they directly plug together). Please note that no calibration is required for this sensor.
4. Open the NeuLog application by clicking on the shortcut on the screen.
5. Once a motion sensor module box appears on the left side of the screen the probe has been automatically identified and you can begin experimentation.
6. If the motion sensor is not automatically identified then click the "Search for sensors" icon to find the sensor.
7. Click on the "On-line experiment" icon; this will open a graph below.
8. Click on the "Module setup" button located in the motion sensor module box to change the sensor's settings if need be.
9. Click on the "Experiment setup" icon to change the experiment settings if need be (experiment duration for example).
10. The motion sensor will give a live reading in the module box to the left of the screen while plugged in.
11. To run an experiment and collect data click the "Run experiment" icon.
12. To end data collection early, click the "Stop experiment" icon.

Tablet, smart phone device

Materials needed:

- NUL-213 Motion Sensor
- WIFI-201 WiFi Module
- BAT-200 Battery Module

Your motion sensor needs to be connected to a WIFI-201 module. The WIFI-201 module will create a closed NeuLog WiFi network which will stream the NeuLog data to a device of your choosing. Once your device is wirelessly connected to the NeuLog network, you can run experiments and collect data through a browser of your choosing.

Procedure:

1. Connect the motion sensor directly to the left side of a WIFI-201 module (no wires required).
2. Connect a BAT-200 module to the right side of the WIFI-201 module.
3. Although not required, we recommend plugging the BAT-200 to an outlet using a USB to mini USB charger (such as a typical cell phone charger). The WIFI-201 module will run for 60-90 minutes (depending on the sensor) without being plugged in.
4. The WIFI-201 module can be powered directly using a mini to USB cord and plugging it into your computer or a wall charger. Please note this function is only available on WIFI-201 modules with the USB icon on the cover.
5. For further WIFI-201 instructions or the WIFI-201 quick start guide please visit: www.NeuLog.com; Choose "Products" on the main menu, then choose "WiFi Communication module".
6. The WIFI-201 indicator lights will flash; take no action until the LED to the far left turns blue; this can take up to one minute.
7. Take your tablet or smart phone, go to the WiFi settings and select the NeuLog network (NeuLog0184 for example) which matches the ID found on the back of the WIFI-201 module (0184 for example).
8. Give your device about 20 seconds to connect to the WIFI-201 module.
9. Once the device is connected, go to your browser and type the website wifi201.com into the URL bar, then wait for 30-60 seconds.
10. You will see a "Control mode" icon in the application, click on it.
11. The application will then load a new screen and begin to auto detect the sensor(s); this can take a minute. (You can stop the search when the sensor is found.)

NEULOG MOTION LOGGER SENSOR GUIDE



12. If the application does not auto detect the sensor(s), select “Search for sensors”.
13. Once the sensor is found you will see a module box on the left side of the screen for the motion sensor. In this box, real time data will be displayed.
14. Click on the “Module setup” button located in the motion sensor module box to change the motion probe settings if need be.
15. Click on the “Experiment setup” icon to change the experiment settings if need be (Experiment duration for example).
16. To run an experiment and collect data, click on the “On-Line experiment” icon, then click the “Run experiment” icon.
17. If you have a newer generation WIFI-201 module (with the USB icon on the cover) this can be used as a USB-200, meaning you can tether the probes directly to the computer using the WIFI-201. To engage operation in this fashion, press 3 times on the panel button. Repeating this operation will return the module to WiFi mode.

Operation with NeuLog Graphic Display Module (viewer)

Materials needed:

- NUL-213 Motion Sensor
- VIEW-101 Viewing Module
- BAT-200 Battery Module

Procedure:

1. Connect the motion sensor to the left side of the viewer.
2. Connect the BAT-200 module to the right side of the viewer.
3. The VIEW-101 will auto detect the sensor and you will see it appear on the left side of the screen.
4. Once the sensor appears it will be monitoring data in real time.
5. To run an experiment and collect data click the run icon (little green person).

Off-line experiments

(Off-line experiments are when you do not have a sensor connected directly to a computer, tablet, smartphone, or NeuLog viewer).

Materials needed:

- NUL-213 Motion Sensor
- BAT-200 Battery Module

Materials needed to configure your offline experiment:

- USB-200 Module, WIFI-201 module or VIEW-101 Module
- USB to mini USB cable (included with the USB-200 module)

Procedure:

1. To determine the experiment settings, first connect to your chosen device (PC, Mac, tablet, smart device) and click on the “Off-line experiment” icon after the sensor search has ended. (For more information on how to change the experiment settings, view the quick start procedure section for your chosen device in this document.)
2. Connect the motion sensor directly to the left side of a charged BAT-200 module.
3. When ready to collect data press the “Start/Stop” button on the motion sensor, a red light will turn on for the duration of the experiment.
4. After the experiment has concluded (the “Start/Stop” button is pressed again or the data collection period ends) connect the sensor to your chosen device (you can find full instructions in each device’s quick start procedure section).
5. Open NeuLog application.
6. Click the “Off-line experiment” icon.
7. Click the “Load data from sensors” icon.
8. Select which experimental data to upload. (5 experimental runs can be stored at one time on the NUL-213 motion sensor)

Restoring sensor’s factory default settings:

Procedure:

1. Connect the USB-200 module to a PC, Mac, tablet, or smart device.
2. Connect the motion sensor to a USB-200 module (they directly plug together).
3. Open the NeuLog application.
4. Click the “Tools” icon.
5. Click the “Restore sensor’s factory defaults” on the menu.

NEULOG MOTION LOGGER SENSOR GUIDE



Included with the sensor:

- NeuLog NUL-213 Motion Sensor Guide (this document)
- Attached metal ultrasonic wave emitter

Sensor specifications:

	Distance	Velocity	Acceleration
Range and operation modes	0.25 to 6.0 m	±10 m/s	±100 m/s ²
ADC resolution	13 bit		
Resolution	1 mm	0.21 m/s	0.45 m/s ²
Max sample rate (S/sec)	100		

Experiment Duration: 1 second to 31 days.

Sensor features:

- Fully digital data
 - Rugged plastic ergonomic case
 - Push button switch to Start/Stop experiments in off line mode
 - LED indicator of experiment status (blinks while collecting data)
 - Pre-calibrated sensing equipment
 - Metal ultrasonic wave emitting/detecting cone with wire mesh covering
- Note:** NeuLog products are intended for educational use.

Videos and experiment examples:

- Videos, literature and other probes can be found at www.NeuLog.com.
- In order to access the motion sensor's page, choose "Products" on the main menu and then "Motion logger sensor".
- In order to find the science experiments, choose "Experiments" on the main menu of the NeuLog website, then choose "Physics", "Chemistry", "Biology" or "Environmental Science".
- Physics Experiments:
 - Falling Objects (P-1)
 - Walking Analysis (P-2)
 - Motion Parameters of a Moving Cart (P-3)
 - Newton's Second Law (P-4)

Technical background:

The philosophy behind NeuLog's plug and play technology is based on each sensor's ability to store its own data due to an internal flash memory chip and micro-controller in each plastic NeuLog body. This technology allows the sensor to collect and then store the digital data in the correct scientific units (°C, °F, Lux, %, ppm, for example).

The sensor is pre-calibrated at the factory. The built-in software in the logger can be upgraded for free at any time using the provided firmware update.

The ultrasonic transducer is a device which converts a pulse train to transmitted ultrasonic pulses that can be sensed and converted back to an electronic pulse train by another similar ultrasonic transducer or by itself.

The ultrasonic transducer is based on ceramic crystal, which is cut in a certain way and is placed between two metal plates.

The crystal is characterized by the piezoelectric effect. Electrical field changes between the plates create mechanical vibrations in the crystal.

The crystal has a resonance frequency. The mechanical vibrations and electrical reactions depend on this resonance frequency.

Supplying pulses to the crystal of the ultrasonic transducer in a rate according to its frequency, causes it to vibrate and to transmit these pulses as an acoustic sound. This sound cannot be heard because it is above the hearing frequency range, usually at 40 KHz.

The acoustic sound can be converted back to electronic pulses by another ultrasonic transducer or by the transmitter when it stops transmitting. The acoustic pulses vibrate this transducer and these vibrations are turned into voltage pulses.

The speed of the ultrasonic wave is 300 m/s because it is a sound wave. For distance measurements, a burst of the transducer frequency wave is sent and the system measures the time between sending and receiving.

$$S = 300 * t$$

Velocity is obtained by calculating the difference between two successive distances divided by the time between the samples (according to the sampling rate).

NEULOG MOTION LOGGER SENSOR GUIDE



Acceleration is obtained by calculating the difference between two successive velocities divided by the time between the samples (according to the sampling rate).

The motion sensor uses a very sophisticated method that enables it to measure a long distance range with a low power of pulses, which allows its use also battery operated.

Maintenance and storage:

- Never submerge the NeuLog plastic body in any liquid.
- Do not allow liquid into the motion sensor's body.
- After use, gently wipe away any foreign material from the motion sensor.
- Store in a box at room temperature out of direct sunlight.

Warranty:

We promise to deliver our sensor free of defects in materials and workmanship. The warranty is for a period of 3 years from the date of purchase and does not cover damage of the product caused by improper use, abuse, or incorrect storage. Sensors with a shelf life such as ion selective probes have a warranty of 1 year. Should you need to act upon the warranty, please contact your distributor. Your sensor will be repaired or replaced.

Thank you for using NeuLog!



Flexible, simple, fast, forward thinking.

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