



Physics Lab Assistant

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About Physics Lab Assistant

What is Physics Lab Assistant?

Physics Lab Assistant is a software application for use introductory physics laboratories with National Instruments data acquisition hardware. It is designed to be a single application that students can use the entire lab course for a wide variety of experiments. It is easy to use, versatile, and computationally powerful. It works with myDAQ, ELVIS workstations, or any DAQmx-based data acquisition device.

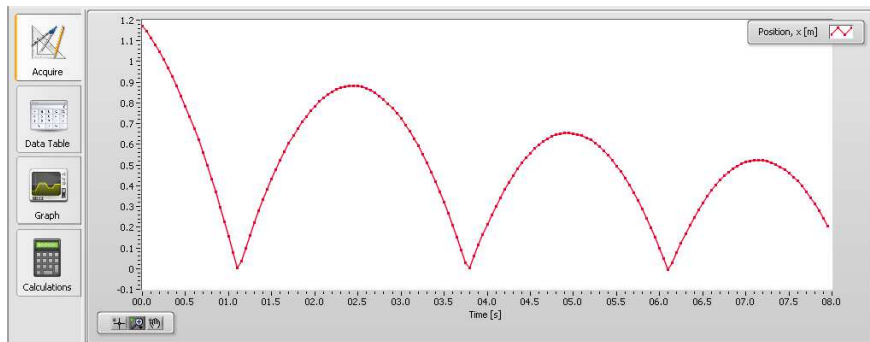
Students can define what measurements they wish to make and what computations that they wish to make from the collected data. In this manner the students are in control of the experiment and are responsible for knowing the physics behind the phenomenon that they are studying.

What can Physics Lab Assistant Do?

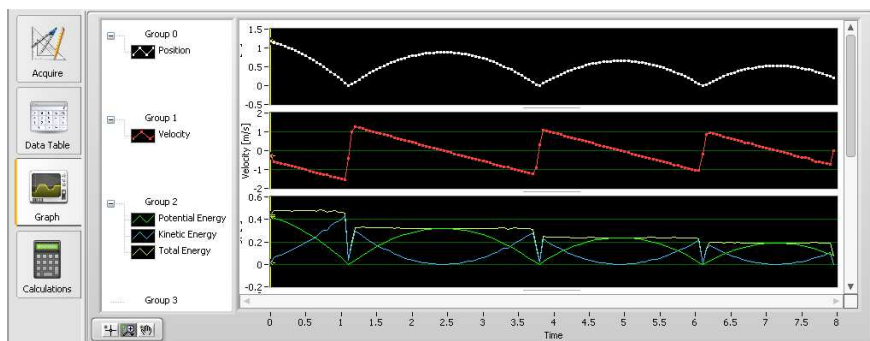
The students can define data channels that are collected from sonic ranger position sensors, any analog sensor (force, temperature, pressure, voltage, strain, etc.), or an encoder. They have opportunity to calibrate the sensors so that the collected data is scaled to the proper units. From here they can calculate additional waveforms such as the derivative or integral of any of the data channels. They can also define a set of constant values and then can define a set of “formula waveforms” that are computed from the data channels, derived channels, and constants using any formula that they enter.

Can I see an example of an experiment?

As an example of a simple experiment using the software consider measuring the position of a glider on an inclined air track. The position (x) of the glider is measured using a sonic ranger position sensor. A partial screenshot showing a sample data set of the position as the glider bounces from the bottom of the air track and rebounds to successively lower heights on the air track due to energy loss at the bounce is shown below.



The student then computes the velocity (v) of the car as the derivative of position. Constants for the angle of incline (q), mass of the glider (m), and the acceleration due to gravity (g) are defined. Then, the gravitational potential energy ($u = m \cdot g \cdot x \cdot \sin(q)$), kinetic energy ($k = (1/2) \cdot m \cdot v^2$), and total energy ($e = k + u$) are computed as “formula waveforms”. The final result clearly shows energy conservation during intervals between collisions with the end of the track and the energy loss at the collisions.



Using Physics Lab Assistant

How do I open the Lab Assistant software?

The installer places a shortcut for *Physics Lab Assistant* on the desktop. You can also start the program from the Start Menu.

How do I create a channel for a sonic ranger?

In Lab Assistant, go to the *Sonic Ranger Channels* tab, near the bottom of the screen, and click *Add*. An *Edit Channel Information* dialog box will appear.

In the *Name* box, type the name of the data you will be gathering (a sonic ranger measures position); in the *Variable* box, type the variable you want to use to represent this data (variable names must be in the form of a letter followed by an optional number); in the *Units* box, type the units you want the data to be measured in. Be sure that the *Channel* box is set to the appropriate channel (1 or 2, depending on which Sonic Ranger port on the Multi-Purpose Lab Interface Box your sonic ranger is connected to). If you know the gain and offset of your sonic ranger you may enter it here. Otherwise you can calibrate your sonic ranger later and use the default gain and offset of 1 and 0 respectively. The display checkbox controls whether the channel will be displayed on graphs. Click *OK*.

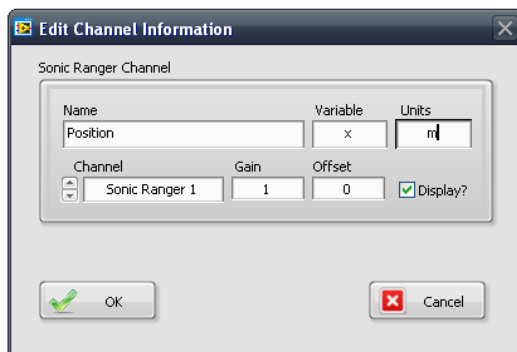


Figure 1: Setting up a sonic ranger channel

The new channel will appear in the list of *Sonic Ranger Channels* as shown in Figure 2 below. If you need to change the parameters for your channel you can double click the entry in the table.

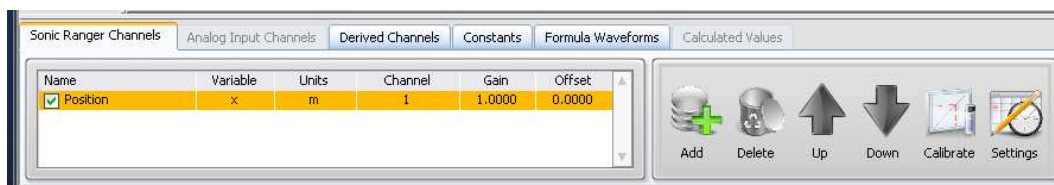


Figure 2: Channel definition for a sonic ranger in channel 1.

How do I calibrate the sonic ranger on an air track?

The sonic ranger can be calibrated to measure position relative to any point, in any units. We could calibrate the sonic ranger to measure the actual distance between itself and an object (usually an air-track glider); however, this is not necessary since we are generally interested in *change in position* of the glider. Since the air track already has a scale, it is most convenient to define the position of the glider to be that measured by the scale. Furthermore, it is easier and more accurate to measure the position of the glider on the scale by measuring the position of one of its ends, rather than the sail.

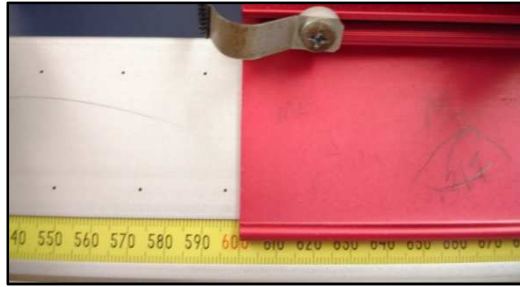


Figure E-3: A glider at a position of 0.600 m

The scales on the air tracks measure millimeters ($1\text{mm}=0.001\text{m}$) or centimeters ($1\text{cm}=0.01\text{m}$). Different air tracks may differ in how they mark positions beyond 1m as shown in Figure E-4.

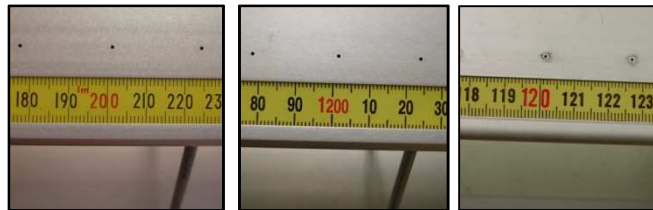


Figure E-4: Three different air tracks all showing the $1.200\text{m} = 1200\text{ mm} = 1.20\text{ cm}$ area

Under the *Sonic Ranger Channels* tab, select the channel you need to calibrate (when selected, it will be highlighted yellow). Click the *Calibrate* button. A *Calibrate Sonic Ranger Channel* dialogue box will appear. Follow the on-screen directions to calibrate the sonic ranger.

Step 1: Alignment Make sure that the switch on top of the sonic ranger is set appropriately (use the narrow beam when on the air track). Click the *Live Graph* button; a *Sonic Ranger Popup Graph* will appear showing the output of the sonic ranger. Move a glider back and forth to make sure the sonic ranger picks up its movement. Click *OK* to close the graph. Click *Next*.

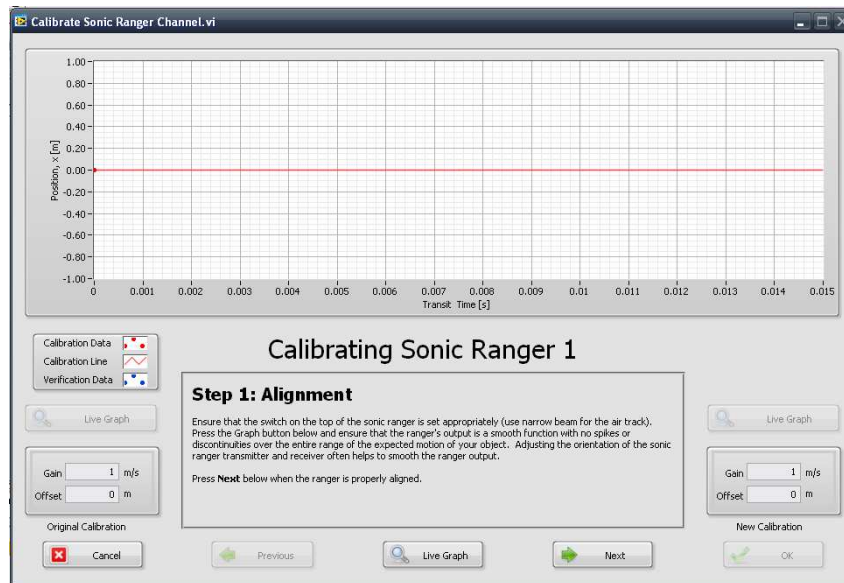


Figure 5: Calibration step 1

Step 2: First Calibration Point Place the glider (or object to be measured) at a known position in front of the ranger. In the *Position 1* box type the position of the glider, using the units specified to the right of the box (usually meters). Click *Read*. A single point will appear on the graph. Click *Next*.

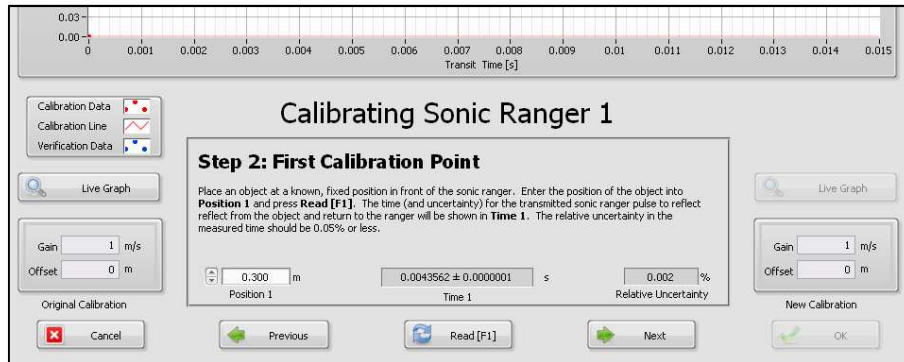


Figure 6: First calibration point at 0.300 m

Step 3: Second Calibration Point Move the glider to a different known position (it's usually best to have the calibration points widely separated), and type the new position into the *Position 2* box. Click *Read*. Another point and a straight line will appear on the graph. Click *Next*.

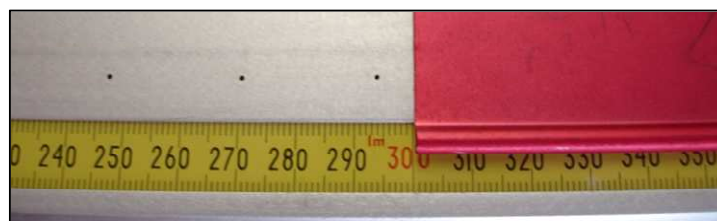
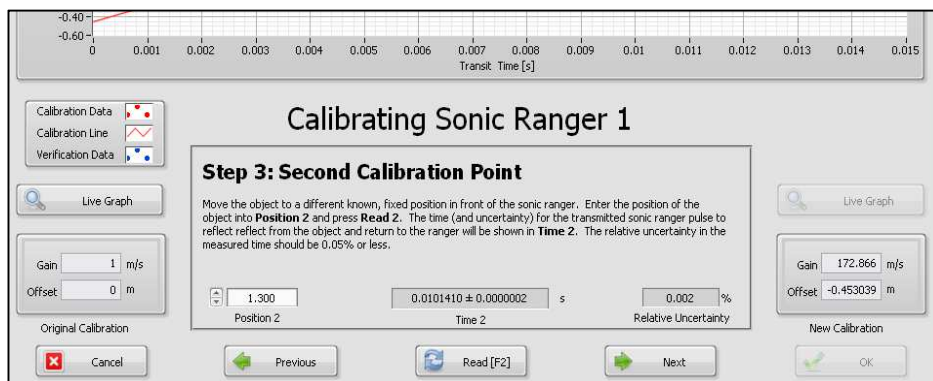


Figure 7: Second calibration point at 1.300m

Step 4: Verify Calibration Move the glider to a third known position, and type the position into the *Actual Position* box. Click *Verify*. The position measured by the sonic ranger will appear in the

Measured Position box. The percent error of the measured position from the actual position will appear in the *Percent Error* box. The percent error should be less than 1%; if it is 1% or greater, you may need to redo the calibration. If so you can click previous to go back and repeat. Otherwise, click *OK*.

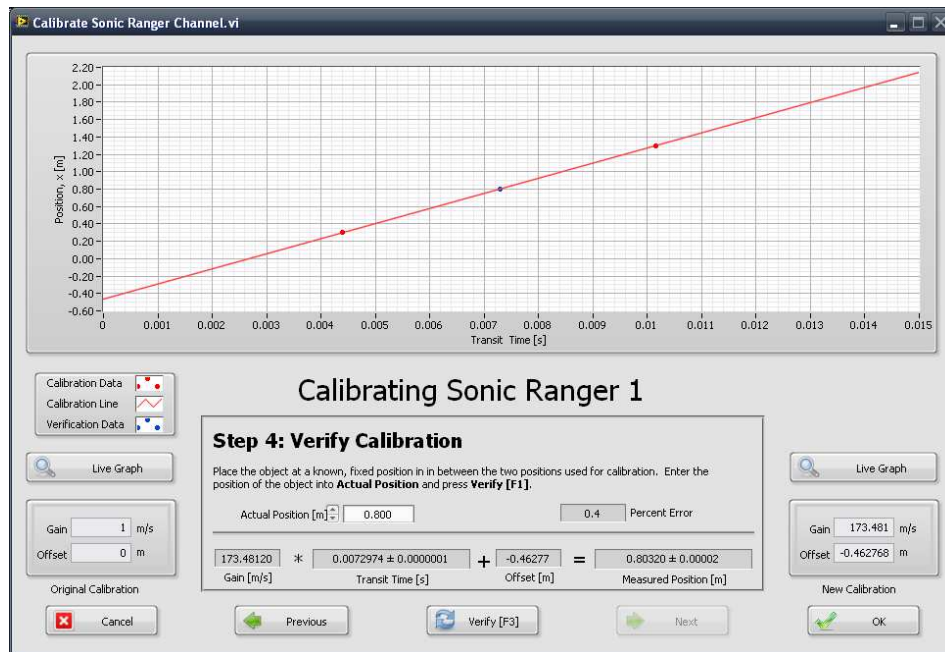


Figure 8: Verifying the calibration using a position at 0.800m

The sonic ranger is now calibrated; a gain and offset will appear to the right in the *Sonic Ranger Channels* box. The gain should be close to 172 m/s (about half the speed of sound).

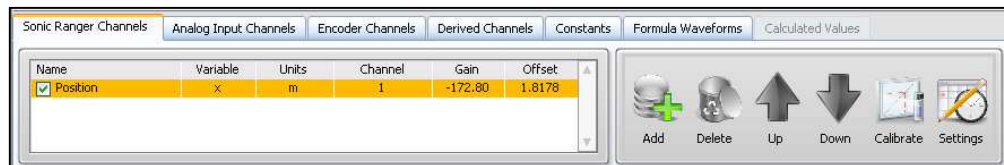


Figure 9: A calibrated sonic ranger position channel

How can I measure force, pressure and similar quantities in Lab Assistant?

In addition to measuring position with a sonic ranger the Lab Assistant software can be used to measure the output of a variety of different types of sensors. Any sensor that has a voltage as its raw output is called an analog sensor and can be measured using an Analog Input Channel. Examples of analog input sensors that we will use include force probes, temperature sensors, and pressure sensors. The cord from these sensors are plugged into one of the analog inputs along the bottom of the input box. Note that above each input there is a place for a pre-amplifier module to be mounted; this is important so that the relatively weak signal from the

sensor is not affected by attempts to read it. This also means you must make sure that you use an input that has a pre-amplifier mounted, otherwise there will be no signal. Note that most of pre-amplifiers used in this course will change the range of the signal as well, which can affect the maximum signal you can read, and what you must enter if you are specifying gain and offset by hand. The most common modules in this lab are:

Module number	Input → output	Notes:
5B31	1V → 5V	5x, good for small signals, but watch for maxing out
5B40	50mV → 5V	100x, no real applications in Physics 256
5B41	10V → 5V	Halves the signal, probably most commonly used.

How do I measure rotational motion?

An encoder is a device that can be used to tell the direction and rate of either linear or rotational motion. When we use a rotary motion encoder we will define a data channel for it on the Encoder Channels tab in Lab Assistant. The rotational motion detector has two leads coming out, which should then be plugged into two custom cables with have both a phono jack and a BNC connector. The two BNC connectors should be attached to the “Clock” and “Gate” connectors on the “CNT 0” or “CNT 1” row in the middle-right side of the panel; these return pulses to the box to be counted. The phono jacks should be plugged into any of the “Digital I/O” plugs across the top left part to provide power. Due to a bug in the software, you may need to also define a dummy analog sensor channel for the timing to work right. Before taking any data, check that one rotation of the wheel is read as one rotation in Lab Assistant. Once in a while inadvertant signals will cause the sensor to change its pulse rate by a factor of four or five, which you can correct for if you are aware of it.

What are the Derived Channels in Lab Assistant?

The Derived Channels tab is used to compute a new waveform that is either the derivative, integral, or power spectrum of any single data channels (Sonic Rangers, Analog Inputs, or Encoders). Our most common use for this tab will be to compute the Velocity of an object as the derivative of the position, and the acceleration as the derivative of the velocity. When doing this one must define the velocity channel first and then the acceleration channel next. Figure 10 shows how to set up a derived channel to calculate the velocity of an object from the derivative of its position.

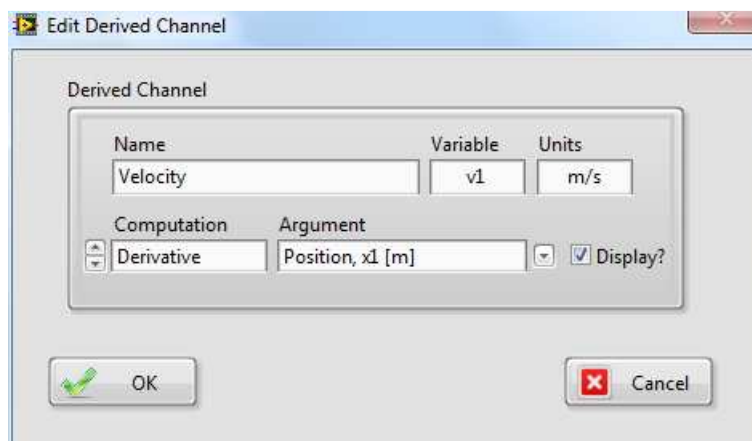


Figure 10: Calculating velocity as the derivative of position.

How do I create a constant value in Lab Assistant?

Constant values can be defined on the Constants tab in Lab Assistant. You must choose a variable name that adheres to the same rules as for data channel variable names, specifically that the variable must be a lower case letter only (*i.e.* g) or a lower case letter followed by a single digit number (*i.e.* m1). Constant values can be used when computing formula waveforms (see below).

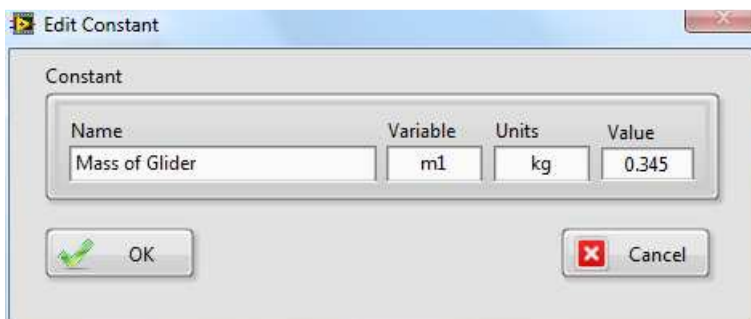


Figure 11: Defining a variable $m1 = 0.345$ kg to represent the mass of a glider

How do I calculate a Formula Waveform in Lab Assistant?

Lab Assistant can be used to calculate a waveform from a formula that is based upon any of the data channels (sonic ranger, analog input, encoders), derived channels, constants, or formula waveforms that are previously defined.

For example, if one measured the position ($x1$) of a falling object with the sonic ranger, calculated the velocity ($v1$) using a derived channel, and defined constants for the mass ($m1$) of the object and the acceleration due to gravity (g), then one could calculate the following Formula Waveforms for the kinetic energy ($k1$), gravitational potential energy ($u1$), and total energy ($e1$) using the formulas:

- Kinetic Energy: $k1 = (1/2)*m1*v1^2$
- Gravitational Potential Energy: $u1 = m1*g*x1$
- Total Mechanical Energy: $e1 = k1 + u1$

In this example it is important that the formulas for the kinetic energy and gravitational potential energy be defined before they are used for the total energy waveform. Care must be taken when entering formulas to be sure that all of the variables used in the formula have been previously defined.

How can I calculate a single numerical value from a waveform?

The Calculated Values tab in Lab Assistant can be used to calculate any of the quantities listed below from any waveform (data waveform, derived waveform, or formula waveform). The range of the waveforms that are used in the computation is based upon the time values that are shown in the waveform graph. You can use the cursor zoom tool to zoom into a specific region of the data to refine how these values are computed.

- Mean – average value of the selected waveform values over the time range shown in the waveform graph.
- Standard Deviation – Standard deviation of the waveform values show in the waveform graph.
- Standard Error – The standard deviation of the mean of the waveform values shown in the waveform graph.
- Slope – The slope of the selected waveform (versus time) over the region shown in the waveform graph.
- Amplitude – The amplitude of the single tone in the selected waveform with the highest amplitude.
- Frequency – The frequency of the single tone in the selected waveform with the highest amplitude.

Where do I go for more information?

Additional information including example experiments, screenshots, and a support forum where you can ask questions of the developer is available at <http://physics.wku.edu/harper/apps/physics-lab-assistant/>.