

Introductory Laboratory on the Physics of Physiology

Background

To directly measure a biological phenomenon it is necessary to link the biological process to some kind of measurement device. For example, if you want to record a bird song, then the sounds produced by the bird must be transformed from a pressure wave in air to an electrical signal in your microphone. How does the microphone work? It operates as a transducer by transducing a pressure wave into a change in voltage at the microphone's surface. Voltage change can now be recorded, analyzed and played back. The focus of today's lab is to give you hands-on experience with a transducer, and proceeding to data acquisition and analysis of a measurement.

Objectives of the lab:

- Learn the physical principles underlying transducers in biology, and the translation of analog to digital data.
- Familiarize with the software (iWorx Labscribe) that controls and interprets the output of the force transducer used in this laboratory.

Post-lab Assignment: Each lab group should turn in the post-lab assignment (see last page of this laboratory manual) before you leave lab (i.e., due at the end of the lab period).

General Principles for running this lab

The general principles of this lab are to use a force transducer to measure the mass of various objects, calibrate the force transducer so that you could figure out the weight of any object, and be able to explain the entire process of the force transducer from hanging the weight to analyzing digital data using LabScribe.

Given that the following labs will be focused on using transducers to measure physiological processes, now is the time to become comfortable with using LabScribe and the general principles of analog to digital conversion.

The easiest place to start is to just explore the program. A fully detailed tutorial is available so that you can step-by- step walk through the major functions of this system.

Once the fundamentals of this transduction are understood, you will use the force transducer to measure the weight of an object, and the LabScribe software to analyze the digital data.

WARNING: Both the balance and the force transducer should not be loaded with any object greater than 100 g.

Note: The force transducer has **two hooks**. Use the first hook for objects in a weight range of 0-1 g, and use the second for objects in a weight range of 0-100 g.

They should not be loaded over their range.

LabScribe Tutorial

Equipment Set-up

- Make sure the FT-302 force transducer is in place, and all the connectors are plugged in.
- Choose the Mac OS X configuration.
- Log on (**User, password on board**).
- Use the power switch to turn on the unit, confirm with a lit green power light.

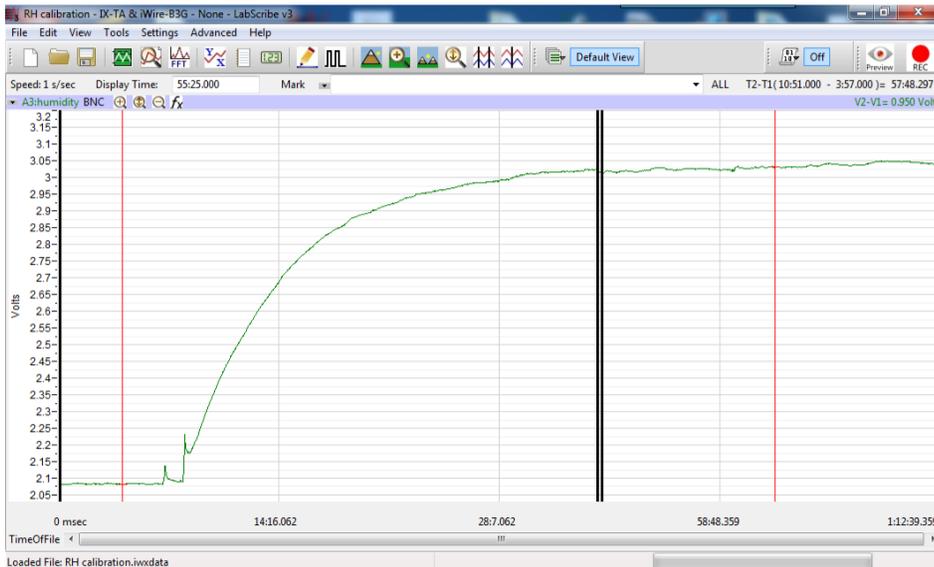
IMPORTANT: You must log on to the computer, **then** turn on the power to the iWorx unit, and **then** load the software – **in that order** - for the components to work properly together.

Start the software

- Click on the **LabScribe** shortcut on the computer's desktop to open the program.
- On the Main window, pull down the **Settings** menu and select **Load Group**.
- In **Complete Settings** locate and open **IPLMv6Complete.iwxgrp file**.
- Pull down the **File** menu and select **Open**; select **CompleteSettings**, open **Animal Muscle** folder, and then the **Crayfish- Heart-IXTA.iworxset** setting file. After a short time, LabScribe will appear on the computer screen as configured by the CrayfishHeart-IXTA settings.

The *LabScribe* user interface contains five primary display windows: the **Main** and **Analysis Windows**, the **XY** and **FFT Views**, and the **Journal**.

Most of *LabScribe*'s interface features can be found in the **Main Window**. *LabScribe* can display up to 128 channels of raw and computed data in the **Main Window**. The CrayfishHeart-IXTA setting displays only one channel.



The LabScribe Main Window.

Many of the functions of *LabScribe* can be accessed via the icons in the **Toolbar**, which is directly beneath the menu headings on the **Main Window** display. These functions are described in more detail in the relevant parts of this tutorial.



The LabScribe Toolbar.

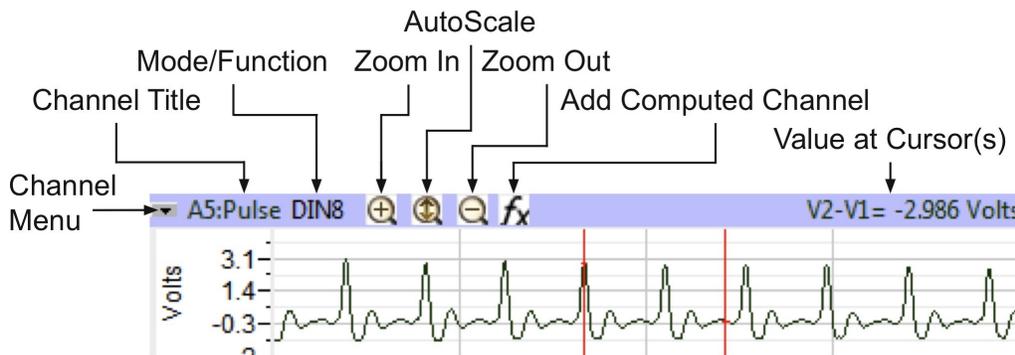
Recording Force Transducer

- Click on the **Record** button, located on the upper right side of the *LabScribe* **Main window**. The signal should begin scrolling across the screen.
- Very gently pull on the hook attached to the force transducer (this should cause no bending of the transducer – *it is sensitive to very small forces*).



- Click on the AutoScale buttons at the upper margins of the channels. The signals should expand to fill the channel window.

- With your fingers tap on the table next to your computer and see what happens to the signal on the recording channel. Can you explain your recording?
- Click **Stop** to halt recording.
- Select **Save As** in the **File** menu, type a NAME for the file. Choose as destination your **Group folder** (LAB PARTNER NAMES). Designate the file type as *.iwxdata. **Group folders** are to reside in the appropriate **Lab Section** folders located within the **Bio 329L Student Data** folder found on the **Desktop**.
- Click on the **Save** button to save the data file.



The Main Window Channel Bar.

Explore the LabScribe Main Window

Once you have recorded data, explore some of the functions of the LabScribe software that are available on the Main window by clicking on buttons, or pulling down menus and selecting functions. See what happens to the images on the recording channels as you change the Display Time, Zoom In or Out, or Invert the signal.

Channel Recording Area: Each channel has its own recording area and its own controls and indicators:

- **Channel Menu** has controls for inverting and copying the graph, hiding and minimizing the channel, changing the title of the channel, converting units, and setting the scale of the Yaxis.
- **Channel Title** can be changed through the **Channels Menu** or the **Preferences** dialogue window.
- **Zoom In** button doubles the height of the signal displayed without altering the real amplitude of the signal.
- **Zoom Out** button halves the height of the signal displayed without altering the real amplitude of the signal.

- **AutoScale** button increases the height of the signal displayed to within 5% of the upper and the lower limits of the Y-axis.
- **Add Function** button opens a pull-down menu used to select a computed function to be performed on the channel.

Time Displays and Mark Controls

- **Speed** is the number of samples taken each second of the recording. Sampling rate is controlled from the Preferences dialogue window on the LabScribe pull-down menu.
- **Display Time** is the length of time of recorded data that is seen on the Main window. Display time is controlled from the **Preferences** dialogue window, which is launched by selecting **Preferences** in the **LabScribe** menu, or by the **Display Time** icons on the LabScribe **toolbar**.
- **Mark** button is clicked to place a mark at a point of interest on a live recording. Clicking the **Enter** key on the keyboard will also add marks to a live recording.
- **Mark Menu** is opened by clicking on the arrow to the right of the Mark button. This menu has controls for adding and deleting preset marks, and resetting the positions of marks.
- **Mark Box** is an area where comments associated with preset marks are composed. Preset marks can be added to a list by using the **Add function** in the **Marks menu**. To activate a preset mark for use, click on the arrow at the right side of the Mark Box and select the preset mark to be used.
- **T2-T1** displays the time of the recording at the position of a single cursor, or the difference in time between the position of two cursors placed on the recording.

LABSCRIBE TOOLBAR



- **Main Window:** Click on this icon to return to the window where recorded data is first displayed and on-line computed functions can be performed.
- **Analysis Window:** Click on this icon to send the data between the left and right margins of the Main window to the Analysis window for additional measurements.
- **FFT:** Click on this icon to perform a Fast Fourier Transform on data for determining the power spectrum of the waveform.
- **XY Plot:** Click on this icon to plot the amplitudes of two channels, like pressure and volume, against each other.

- **Journal:** Click on this icon to open a notepad for recording critical data points, data windows, comments, and responses to questions for their eventual transfer to word processing, graphing, and other programs used for expressing experimental results.
- **Marks Window:** Click on this icon to open the list of marks created during the data recording. The comments associated with the marks can be edited.
- **Stimulator:** Click on this icon to open the Stimulator Control Panel under the toolbar. The type of stimulus and its parameters are selected from the control panel. The stimulator is only needed in experiments that require the generation of action potentials or muscle twitches.

DISPLAY TIME CONTROLS

- **Half Display Time:** Click on this icon to halve the length of the recording displayed on the screen. For example, if ten seconds of data is displayed on the screen, clicking this icon will display only five seconds.
- **Double Display Time:** Click on this icon to double the length of the recording displayed on the screen. For example, if ten seconds of data is displayed on the screen, clicking this icon will display twenty seconds.

In Two Cursor Mode, click the **Zoom Between Cursors** icon to fill the display with the data located between the cursors. You can undo the Zoom Between Cursors by choosing **Undo Zoom Between Cursors** in the **Display** submenu in the **View** menu.

There is a **scrollbar** at the bottom of the window that can be used to scroll through the data. Scrolling can also be achieved by holding down the **COMMAND key**, and clicking and dragging in the graph window.

CURSORS

- **Two Cursors:** Click on this icon to place two cursors on the window. These cursors can be used for measuring the differences in time or amplitude for the positions of the two cursors.
- **One Cursor:** Click on this icon to place a cursor on the window. This cursor can be used for measuring the time and amplitude at the position of the cursor.

Making Marks on a Recording

Large amounts of data can be recorded with LabScribe software. However, to be useful, the data that is interesting needs to be located and retrieved easily. Specific sections of data can be located or distinguished from sections by placing marks and comments at those locations in the data file. Marks, with or without text comments attached, can be placed on the data during or after the recording. The text comments associated with marks can also be composed and

saved, before the recording begins, in the Preset Mark List.

Entering Marks While Recording

Practice adding marks with comments during a recording. During data recording, an active text cursor appears in the Mark Box.

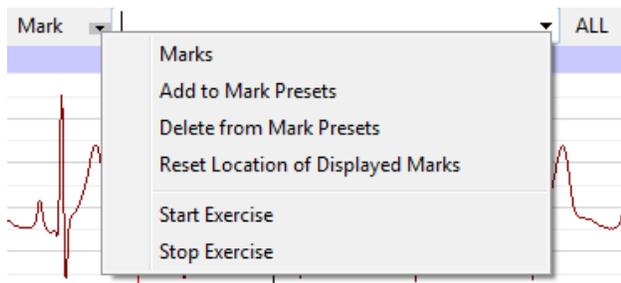
- Type the subject's name in the **Mark** Box using the keyboard.
- Click on the **Mark** button on the **Main** window or press the **Enter** key on the keyboard to place the mark on the recording.



The Mark button and text box.

Making and Entering Preset Marks

- To create and use a preset mark type the mark text in the Marks text box.

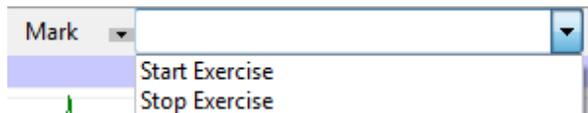


The Mark button and drop-down menu.

- Choose the **Add to Mark Presets** option in the menu that opens by clicking on the arrow to the right of the **Mark** button. This will save the typed text as a preset mark.
- Click Record. Pull down the **Preset Mark List**.

Select the preset mark you composed. The preset mark should appear in the **Mark** Box.

- Click on the **Mark** button on the Main window or press the **Enter** key on the keyboard to place the preset mark on the recording.
- Click on the **Stop** button to end the recording. Open the **File** menu and select **Save**.



The Preset Marks drop-down menu.

- The preset mark can be called by clicking on the arrow to the right of the **Marks text box** and choosing the desired preset mark. This loads the Marks text box with the desired Mark text. Clicking the **Mark** button or striking RETURN will add the preset mark to the record. You can delete a preset mark by selecting a preset mark (using the arrow to the right of the Marks text box) and choosing the **Delete from Mark Presets** option in the drop-down menu next to the **Mark** button.

Entering Marks on Recorded Data

Additional marks and comments can be added to a data file after the recording is completed.

Find a region of interesting data in your current data file.

- Click on the **Single Cursor Mode** icon in the **Toolbar**.
- Position the cursor on the record where the mark is to be positioned.
- Type the text (a maximum of 50 characters) associated with the new mark in the **Mark** text box.
- Click the **Mark** button or press the keyboard's **RETURN key**, and the mark and its text comment are inserted at the current position of the cursor.
- Open the **File** menu and select **Save**.

Analyzing Your Data in the Main Window

Time and amplitude measurements can easily be performed on the **Main** window using cursors. The values obtained can be saved in the Journal along with other notes pertinent to the experiment.

Navigating the Main Window

There are two ways to navigate through a data file in the **Main** window to reach regions of interest: scrolling or using marks.

Making Measurements on the Main Window

USING TWO CURSORS:

- Click on the **Two Cursors** icon in the toolbar to place two vertical red bars on the **Main** window.
- Click on and drag the cursors, to the left or to the right, to place them at the peaks of two adjacent pulses. The difference in time between the peaks is the value labeled **T2-T1**, which is displayed next to the **Mark** box.
- Click on and drag one of the cursors to the baseline of the pulse recording to the left of a force peak. Place the other cursor on the peak to the right of the first cursor. This difference in the amplitude is the value labeled as **V2-V1**, which is displayed at the extreme right of the channel bar.

The Journal

The Journal is a window that can be used as a notebook. Notes about the experiment and values from measurements on the Main window can be typed directly into the Journal. Also, recordings on the screen and data in tables can be copied and pasted into the Journal. From the Journal, the items present can be pasted into other programs, or printed directly.

- Open the **Journal** by either clicking on the **Journal** icon on the toolbar or pulling down the **View menu** and selecting **Journal**.

- In **Editor** use the keyboard to type a note regarding this experiment or the values of the measurements taken with the cursors in the Journal.
- Copy the data on the **Main window** to the clipboard file by selecting the **Copy** command in **Edit** menu.
- Place a text cursor on the Journal window by clicking on the open area of the window. Use the **Paste** icon on the **Journal toolbar**, which is on the top margin of the Journal window, to paste a copy of the data from the Main window into the Journal.
- Open the **File** menu and select **Save**.
- Click on the **Journal** icon on the toolbar or pull down the **View** menu and select **Journal** to close the Journal.

Analyzing Your Data in the Analysis Window

Additional analyses can be performed on data displayed in the Analysis window through a number of functions that include derivatives, integrals, and general parameters.

In the Analysis Window Channel Menu the first three menu items send the values in the Channel Bar Table Functions data boxes to the Journal for formatting and inclusion in reports:

- **Add Ch. Data to Journal:** Sends that channel's title and Table Functions data box values to the Journal.
- **Add All Data to Journal:** Sends the channel titles and the values from the Table Functions data boxes in the Channel Bars of all channels to the Journal.
- **Add Title to Journal:** Sends the Title(s) from the Table Functions data box title bar to the Journal.

Navigating in the Analysis Window

- Locate a five-second section of the recording in the **Main window**.
- Click on the **Analysis window** icon in the toolbar or select **Analysis** from the **View** menu to transfer the data displayed in the Main window to the Analysis window.

Channels and data are displayed on the Analysis window as they are on the Main window.

However, you will find that some displays, like Value or Time, will appear in tables above each channel.

- Pull down the **Channel menu** to copy, hide, delete the selected channel, and more. Other functions allow data to be copied from the Analysis window to the Journal in tabular format.

Making Measurements on the Analysis Window

Measurements on data displayed in the **Analysis window** are performed using cursors and functions selected in the following manner:

For specific setting files some functions are already pre-selected. For this exercise you opened **Crayfish- Heart-IXTA.iworxset** setting file and the functions pre-selected are:

Value2 - amplitude at which the cursor 2 is positioned;

V2-V1 - difference in amplitude between the two cursors;

T2-T1 - time between the two cursors.

You can add other functions clicking on the **add function** button to open a menu of mathematical functions that can be performed on the data displayed in the **Analysis** window.

Open the **submenus** to familiarize yourself with the parameters available in each category:

- **General**: provides amplitudes and times of the data at the positions of the cursors, differences in amplitudes and times between the data, the maximum and minimum values of the data between the cursors, and more.
- **Derivative**: provides the slope of the data at the positions of the cursors, and the maximum, minimum, and mean slope of the data between the cursors.
- **Integral**: provides the area or absolute area under the recording, or the integral or the absolute integral of the recording, between the cursors.

Physics of Physiology

Post-lab Assignment (*turn in one per group*)

Student Names: _____

a) What did you learn by tapping on the table during recording?

b) Weight of the “prize” *in Newtons*: _____

c) Draw a diagram and/or use a few words to explain how a force transducer can be used to study muscle contractions: