Lab 1: Introduction to Data Acquisition

Animal hearts pump blood in a pulsatile manner. Because vertebrates have a closed circulatory system in which the blood is always enclosed within a a pump or blood vessels, it may be possible to detect the pulse, even in the extremities.

The pulse is an excellent proxy for metabolic rate. Increases in metabolic rate require greater oxygen delivery, which will require either faster pumping or stronger pumping.

Questions to consider: Physiological measurements rely on sensors. In this lab we will detect the pulse using a finger pulse transducer. How small a signal can be detected? What physical characteristics are being detected? How can we confirm the signal? Will your results correspond to how you understand heart function?

Practical Learning: you will learn how to acquire data with the PowerLab Data Acquisition Unit and LabChart software.

The **Lab Manual** (this document) describes the experiment for today.
Standard procedures are described in the **Lab Protocols**. Please read **Protocol 1+2** for today. The Manufacturer provides a **Quick Reference Guide** for more details (see binder). You will refer to all three today.

Before you leave, make sure you can set up the equipment, operate the software, and have the ability to record, optimize the display of the signal, and annotate, extract, and save data without looking at the manual. **You will have a practical exam on this next week.**

Materials:

- Human volunteer
- PowerLab DAQ
- Finger pulse transducer [MLT1010]
- LabChart software

Exercises:

Prior to recording data, it is always important to run tests to ensure that you are measuring the correct signal and that it is optimized. Note in your notebook how to do essential tasks, it will help you remember.

Exercise 1: Setup and Testing

1. Setup the PowerLab and the finger pulse transducer (see Protocol 1). Start recording.

2. Testing Equipment
- What happens if the hand moves? Write that observation down in your notebook
- If you have trouble recording a strong pulse, try moving the transducer to the index finger or thumb. A few minutes may be required to stabilize the signal.
- What tension of the Velcro strap was best for getting good results? Take notes.

Exercise 2: Recording

It is **critical** that you learn how to **(1) choose a good sampling rate**, and **(2) annotate or comment your data as you record**.

1. **Record** 20 seconds of data and then stop the recording.

2. Find three ways to adjust the **scaling of the Y-axis** (consult the LabChart **Quick Reference Guide** - Check the table of contents on page ii). Note in your notebook.

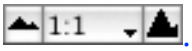
   Double-clicking on the grey box around the Y-axis toggles the display between showing only values above zero in the data display area (single-sided), showing the full range of positive and negative values (bipolar), and showing the data scaled to fit the display area (auto-scaled). These options can also be chosen directly from the Scale pop-up menu for the channel (above scaling buttons).

3. Learn how to **Insert Comments** (annotations) on your waveform (check **Quick Reference Guide**). ***Adding comments accurately on the timeline is a critical part of data collection.***

Note: Comments can be added in real time during recording by typing in the comment box. Just hit return to place it on the timeline. Comments can also be added or edited after recording. Make sure you know how to do all of these today. See the LabChart Quick Reference for more details.

   a. Click on one of the comments you've added to read it in full. Figure out how to (1) move the comment to a different time point, and (2) add a comment after stopping the recording.

4. Play with the **sampling rate** (protocol 1.2). It is on the upper right corner of the waveform window, set at 400/s. **A rule of thumb is that** ***the sampling rate should be at least 10x greater than the frequency of the signal you are trying to record.***

   a. The human heart rate at rest should be about 60bpm, which translates to once per second or 1/s. Record at varying frequencies starting from very slow to very fast — record for 5sec each at 1/s, 10/s, 100/s, 200/s (you can change sampling rate while recording on the fly). Expand/contract the time axis for a better view of the waveform using the view buttons 

. ***What happens as you sample at once per second to 200x per second? Why?*** Remember that while the graph looks continuous, the data is captured at discrete time intervals.

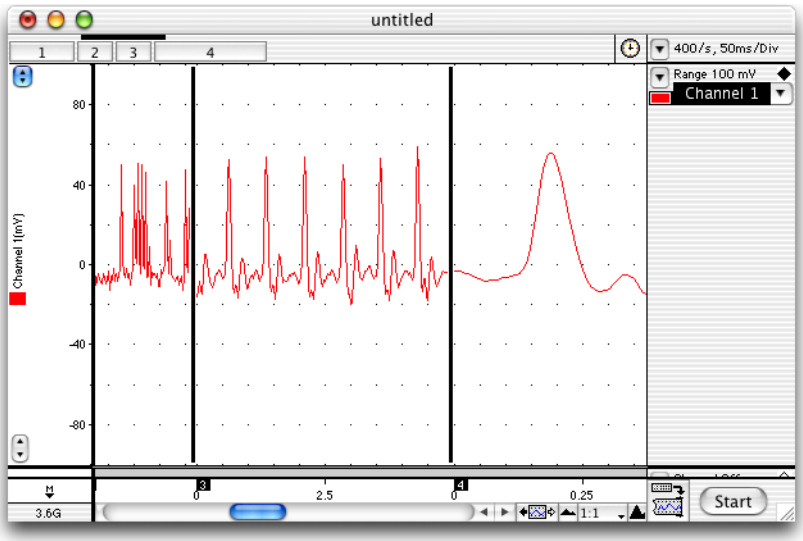


Figure 1. Waveforms you might see when changing sampling rates.

5. **Save your file frequently.** Create a folder on the desktop for your Lab Group and save all your files there each week. Name your file with your names and experiment.

Exercise 2 Questions (Write answers in your Lab Notebook)

1. Note the three ways you can change the Y axis scale.

2. Why is recording at ~10x faster than the signal frequency a good rule of thumb? What kinds of errors can be caused if the recording is too slow or too fast? How does this happen? *Hint: What do the peaks and valleys look like? and what does this have to do with sampling?*

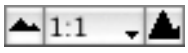
3. Why is it important to comment in real time while you are conducting the experiment? Think about what happens if you forget and come back to your data a few days later.

Exercise 3: Analysis

We will scroll to find data, measuring amplitude and time values from the waveform, place markers, and use the Zoom window for a more detailed view. Refer to Quick Reference as needed.

1. **Navigating the Chart Window. Three ways:**

   a. Via the scroll bar. 

   b. Compress/expand time axis using view buttons.  Try mountains and numbers.

   c. Use Comments to navigate. Window > Comments & Exclusions.

2. **Make amplitude and time measurements with the Waveform Cursor.**

   a. Learn how to use the **waveform cursor**. Find the rate/time and rate/amplitude displays.

   The amplitude (height or magnitude of the wave) is the Y-axis value and the time is the X-axis value. To measure differences in amplitude or time you can use the marker.

   b. Learn how to drop a **marker** on your waveform. Move it to the top of one peak.

   c. Take a peak-to-trough measurement. Take a peak-to-peak measurement. Which measurement is indicated by change in amplitude? change in time?

3. **Use the Zoom window to get a better view of the data.**

   a. Use the zoom window to crop and copy a good example of your waveform.

   b. Use the Marker and Waveform Cursor to measure pulse amplitude and time interval in the zoom window.

   c. Copy and paste your zoom window (command-C on Mac, control-C on PC) to another document to produce a figure.

5. **Using thresholds to count peaks** (automate rate calculations) and display the resulting

heart rate in channel 2. Follow the **Quick Reference Guide** "Cyclic Measurements"

a. For the type of threshold ("detection setting") try general - "simple threshold". You can also try "sine shape".

b. "Events" will be counted when the trace crosses the threshold and returns. The rate will be calculated from the number of events per unit time. What happens when you move the threshold?

c. Record about 5 minutes of new heartbeat data. Does the computed rate seem reasonable? How can you verify?

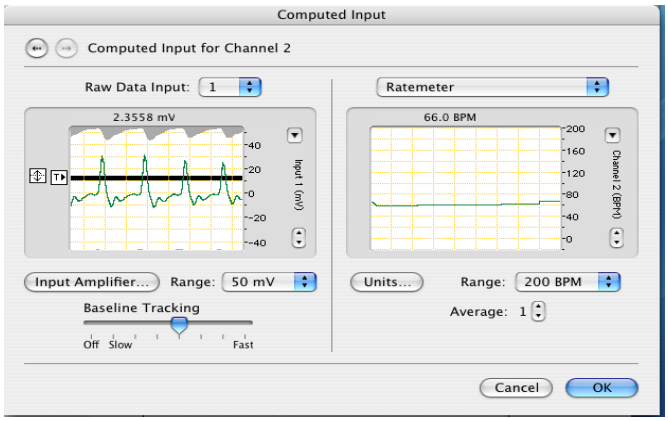


Figure 2. Computed input panel showing placement and width of selection line for computed input in left panel, and ratemeter data in right panel (this is the old display).

6. **Noise Reduction.** There are two types of noise filters: "High Pass" and "Low Pass." The Low Pass filter allows any signal with a frequency below a specified cutoff frequency through, but will block any signal with higher frequency.

   a. The filters are in the "Input Amplifier" pulldown menu for each channel.

   b. Since a human heartbeat is generally going to be below 200 beats/minute, we can safely set a lowpass filter of 5Hz (= 5 events/second or 300 events/minute). What happens?

   c. Do any highpass filter settings improve the signal? (skip if you don't see one)

   d. The "Mains Filter," filters out electrical noise of 50-60 Hz.

7. **Data Pad** The data pads are useful for displaying a summary of the data in the selected region of your recording. Use a block of data with both pulse wave and heart rate (see **Quick Reference Guide** if you get stuck).

   a. Use the datapad to compute the mean and any other statistic you are interested in. Click on the **column header** to see the options for calculations.

   b. Manipulate the data selection and see how the datapad changes.

8. **Macros (skip for today)** A macro records combination of commands and operations so that you can automate your analysis.

a. Write a macro that selects 10 seconds of data at a time. "Macro">"Start Recording." Everything that you do now (keystrokes, mouse clicks, selections) will be recorded by the computer.

b. Activate the "Macro Commands" menu and select "Repeat Select Every…" 10 seconds, and select the button for "block containing selection." This will only run the macro in the block of data you select.

c. Go to the "Commands" menu. Select "Add to Data Pad." Go to the "Macro" menu and click on "Stop Recording." Name this macro and save it.

d. Run the macro (click "macro" under demonstration click your saved title). What happened? Check the Data Pad.

e. Write a new macro that records the data in 1 minute bins. What happens to the variation of the data when you lengthen the sampling time?

11. **Display multiple traces** in the Zoom window. Close the Zoom window, if it is open.

    a. If you only have 1 channel, open a new one by move the pointer to the channel separator near the bottom of the Chart window and drag it up to display a new channel. Turn on the new channel from pop-up menu.

    b. Record capturing the two traces — the finger pulse (on Channel 1) and a straight line (on Channel 2). Click the Stop button.

    c. Select a sample of the data, highlighting both traces.

    d. Select Window > Zoom.

The traces can be overlaid or viewed separately in the Zoom Window by clicking on the buttons at the upper right of the window. (see Zoom in **Quick Reference Guide**)

A second way to select multiple traces is:

    f. Close any open Zoom window.

    g. Highlight data in one channel.

    h. While holding down the Shift key, drag across an area of data in a second channel. Repeat as required for different traces.

There are a couple of advantages to this method: it permits you to select only the traces you want, and allows you to 'crop' to the trace and its immediate area.

Exercise 3 Questions (write in lab notebook)

1. What useful information do you get from a peak-to-peak measurement? Peak-to-trough? Write down their units. Are they the same?

2. How does the marker help?

3. What happens if you set the threshold too high? Too low?

Exercise 4: Validation and Comparison

Validate your heart rate measurements by comparing different methods.

1. Measure your resting heart rate by:
    a. Palpate your writs and count the number of pulses over 15 sec. Convert to per minute.
    b. Recording finger pulse and counting # peaks/ time interval.
    c. Calculate your heart rate from the peak-to-trough or peak-to-peak measurement. (Which one is correct?)
    d. Calculate your heart rate by setting a threshold and using the rate meter.
2. Raise your heart rate by running up and down the stairs or doing 50 jumping jacks. Repeat measurements 1a-d.

Save all your data (Protocol 1.3), both raw data & datapad data.

Questions for thought

1. Do your results conform to what you understand about heart function and the pulse? Can you identify specific aspects of the data that demonstrate heart function?
2. Which can be used to calculate heart rate, peak-to-peak or peak-to-trough measurements? Which can be a measure of stroke volume (blood pumped per contraction of the heart)?
3. Are your confident that your sensors have accurately captured heart rate? How have you validated your methods? Explain. (You may want to think about what you learned in the earlier parts of the lab).
4. What other types of studies might these techniques be useful for?