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Protocol 1: Introduction to Data Acquisition

The purpose of the PowerLab system is to acquire, store, and analyze data. Physiological measurements that we will collect include the finger pulse, blood pressure, respiration, and even more complicated measurements like an ECG (heart), EMG (muscle), EEG (brain waves), nerve conduction. We connect instruments called "transducers" to the PowerLab to measure changes on the body such as pressure, temperature, motion, volume changes, voltage, etc. The raw input signal from the transducer is in the form of an analog voltage whose amplitude varies continuously over time.

One of our main concerns in physiological recording is getting a good signal through the background electrical noise. There are many sources of noise which obscure the signal: unwanted voltage signal from movements, shaking, building vibration, overhead lights and stray electricity, etc. In addition, in some experiments there may be drift in the signal (the baseline slowly changing through time).

The PowerLab can be used for *signal conditioning:* producing a good signal through amplification, filtering, and zeroing (removing an unwanted steady offset voltage from a transducer's output). After signal conditioning, the analog voltage is sampled at regular intervals, and converted from analog to digital form in order to save it on the attached computer (Figure 1). The software can also easily manipulate and analyze the data in a variety of ways.

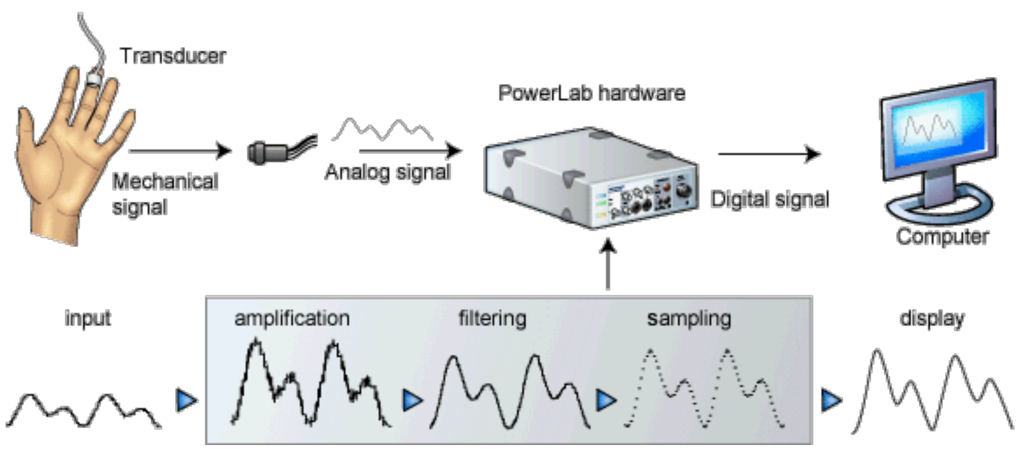
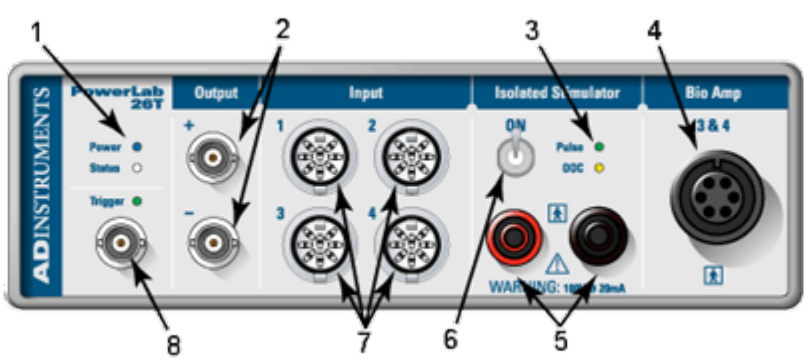


Figure 1. A summary of data acquisition using a PowerLab system.

The 4-channel PowerLab has inputs on its front panel where transducers can be connected. Note that only one input port can be used per channel. It can also generate output signals. We have 3 different PowerLab models in the lab, so yours might look slightly different, but they all work the same. The front of PowerLab 26T and 4/25 (red and blue versions) are shown in Figure 2.



1. Power indicator light: illuminates when the PowerLab is turned on
2. Analog output connections: provide a voltage output in the 10 V range
   This is NOT safe for direct connection to humans
3. Isolated Stimulator status light: indicates if the Isolated Stimulator is working properly (green) or out of compliance (yellow)
4. Dual Bio Amp input: connects a 5 lead Bio Amp cable to the PowerLab; reads as inputs 3 and 4
5. Isolated Stimulator outputs: for connecting stimulating electrodes to the Isolated Stimulator
6. Isolated Stimulator switch: turns on/off the Isolated Stimulator
7. Pod ports: 8-pin connectors for attaching pods and certain transducers to Input; these supply a DC Power to the pods and transducers
8. Trigger input: can be used to start or stop a recording event

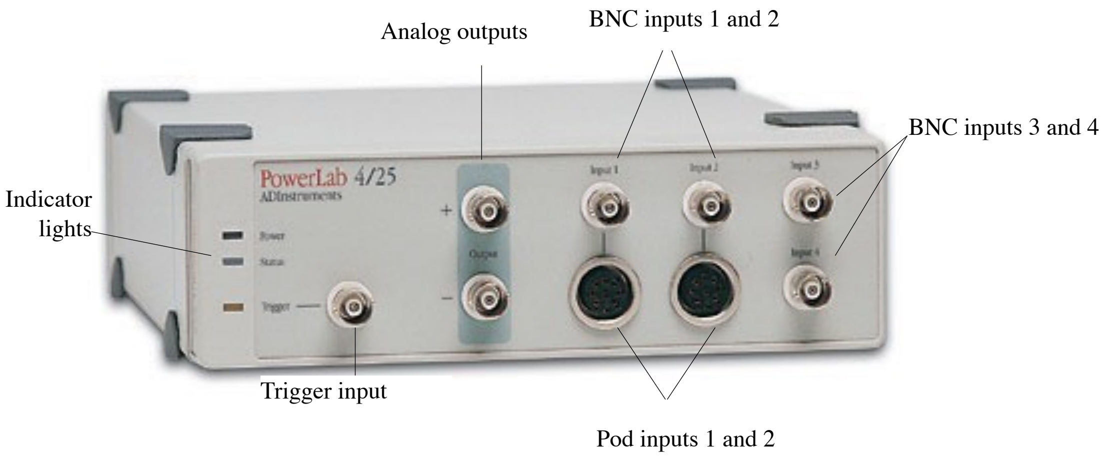


Figure 2. The front panel of the PowerLab 26T (top) and 4/25 (bottom). The look a little different but serve the same functions. We have 2 versions of 4/25 - red letter or blue letter models.

The Chart software controls the PowerLab hardware. The display format resembles a traditional chart recorder, with a scrolling area of the window acting as the paper.

Protocol 1.1: PowerLab Setup

1. Connect the PowerLab to the computer via the USB cable and connect the power cable to power. Turn on the PowerLab so that when you start the Lab Chart software, the computer will be able to detect the unit.

2. Start the Lab Chart software. The chart window is divided into a number of recording channels. By default the blank Chart window will show 8 channels.

3. Another way to start Lab Chart is double clicking on a settings file. The Physiology Lab folder on the desktop contains settings for our experiments. The Chart will be configured for the proper number of channels and with the appropriate settings for specific kinds of recording.

4. When your experiment is complete, be sure to save your raw data as a “chart data” file (a text file).

Protocol 1.2: Finger Pulse Transducer Setup

1. Connect the finger pulse transducer to Input 1 on the PowerLab. On the 26T it will be a

pod connector, on the 4/25 it will be a BNC connector.

2. Place the pressure pad of the finger pulse transducer against the distal segment (the tip) of the middle finger. Use the Velcro strap to attach it just enough so that it won't slip or fall (Fig. 1). This is a sensitive mechanical transducer so do not squeeze or press it.

If the strap is too loose, the signal will be weak, intermittent, or noisy. If the strap is too tight, this will cut off blood flow to the finger, producing no signal and pain.

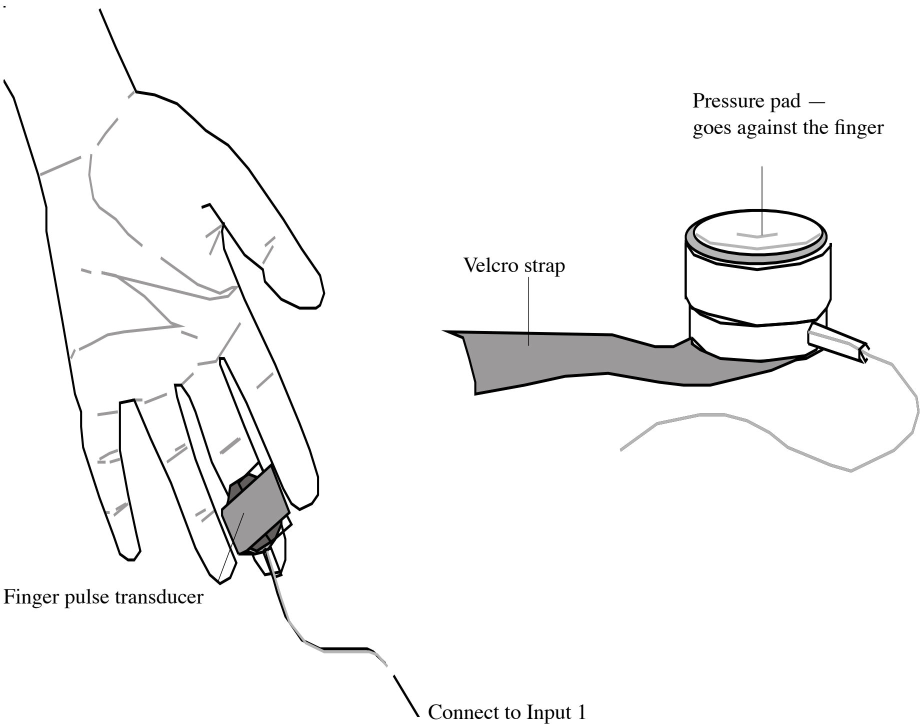
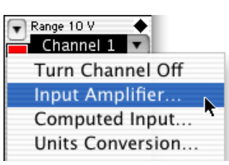


Figure 1. Connecting the finger pulse transducer to the PowerLab and the finger.

Use the Input Amplifier dialog box to optimally display signal

IMPORTANT: If you have the display range set to values inappropriate for your signal, you may not be able to see your signal at all. For example, measuring the diameter of your hair with a meter stick will not be very accurate – you'll get a much better measurement if you match the scale of the ruler to the hair.



1. Find the pop-up menu from the Channel label. Choose **Input Amplifier**.

2. Adjust the sensitivity of the channel by changing the range setting. The number indicates the maximum input voltage (i.e., the 10 V indicates ±10 V). Try a number of ranges to find

a nice waveform that fills about a third of the window (Figure 2). Did the signal change in magnitude?

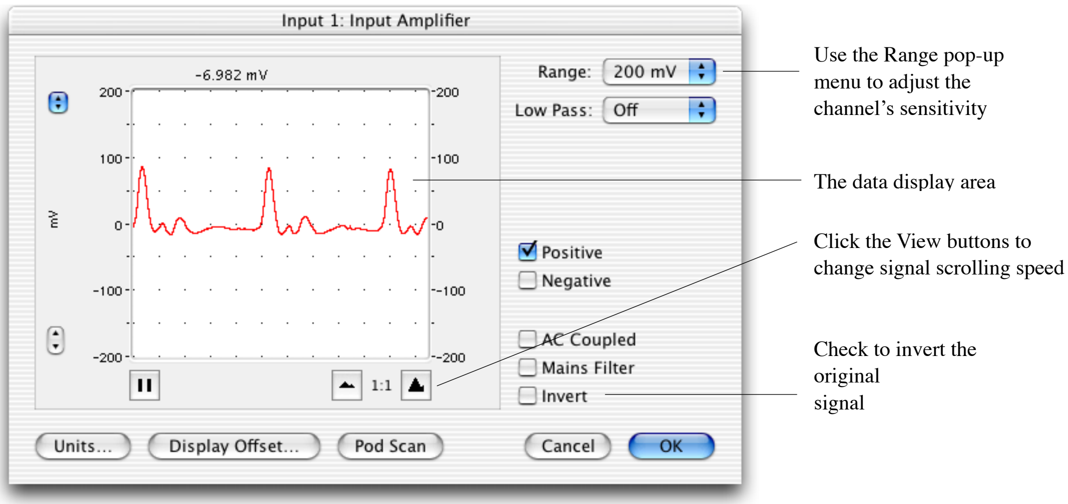


Figure 2. The Input Amplifier dialog box.

Protocol 1.3: Saving Data

Save the data to Text files for Excel or later analysis

You may use Google Sheets or Microsoft Excel to analyze data, graph results, or produce statistical results, or any software packages of your choice.

Save as "Chart data" to save the raw data (the entire chart record) as a text file. The other option is just to save the contents of the data pad (your processed measurements) as a text file. *Save both so that you can go back to the raw data (Chart data) if you need to*. Open the data pad text file in Google sheets. Install Chart reader software onto your home computer for this purpose.

Saving Chart files for use on a PC (Windows 2000, XP)

You can work with your data in LabChart on your PC or Mac as long as you **save the file in Chart for Windows format**. To do this, in the "Save As" menu, select file format "Chart (win)" to save the file with the **.adicht** suffix.

Install LabChart reader on your home computer (the reader version) from the ADI website: https://www.adinstruments.com/products/labchart/versions-and-licenses

Protocol 2: Measuring Blood Pressure

Protocol 2.1: Via Auscultation (listening through stethoscope)

The estimate of blood pressure is obtained by cutting off blood flow with a known pressure (measured by the sphygnomanometer) and slowly releasing pressure until blood pressure is strong enough to counteract the pressure of the cuff. The stethoscope is used to identify the pressure at which flow is restored, by listening for the sounds.

The cuff is placed on the upper arm and inflated to stop arterial blood flow. The cuff creates a high pressure that causes the brachial artery to collapse, stopping blood flow. It is important to release the pressure in the cuff slowly, so as to distinguish systolic and diastolic pressure. When the systolic pressure in the artery is greater than that in the cuff, blood begins to spurt through the partially collapsed artery. This can be heard through a stethoscope as sharp, tapping sounds (Korotkoff sounds), at which stage cuff pressure read as systolic pressure. As cuff pressure is reduced further, the sounds increase in intensity and then suddenly become muffled. Cuff pressure at the point of sound muffling is taken to approximate diastolic blood pressure. As cuff pressure is further reduced much below diastolic pressure, the sounds disappear completely, and normal flow through the artery is re-established. Since the disappearance of sound is easier to detect than muffling, and since the two occur within a few millimeters of mercury pressure, the disappearance of sound is commonly used to determine diastolic pressure.

!!!! Warnings !!!!

This procedure involves stopping blood flow to the arm, which can be painful and potentially dangerous if prolonged or done improperly. NOTE:

1. Any students with a known medical condition that affects their circulation (i.e., hypertension, heart condition), should not participate as volunteers.
2. Do a dry run without cutting off the circulation of the volunteer. Make sure you understand the step-by-step details before attempting it on a person.
3. Do not leave the cuff inflated for a prolonged time (i.e., more than 60 seconds).
4. **Deflate the cuff as soon as** you have acquired the data (don't leave it inflated!!)
5. The volunteer should reestablish blood flow in their arm between measurements by flexing and extending his or her fingers. Rest if needed. Alternate volunteers to maximize breaks between measurements on each person.
6. Medical interpretation of the lab results are not warranted because of potential operator error. Please see a medical professional if you have any concerns about your blood pressure.

Using a stethoscope

A stethoscope is basically a hollow endpiece connected by hollow tubes to earpieces (Figure 1). Most stethoscopes have an endpiece with a flat diaphragm and a concave bell, only one of which is directly connected to the earpieces at any one time. The endpiece can be turned 180° to change the working side. In most stethoscopes, the connection bends away from the side of the endpiece that should be placed against the skin. The bell is generally better than the diaphragm for these lab sessions because it reduces room noise. (If you have the connection the wrong way around, you will hear only room noise.) *The earpieces should point slightly forward to match the direction of the external auditory canal.*

Figure 1. The correct use of a stethoscope: note the angle of the connection to the endpiece; it shows that the bell is currently selected.

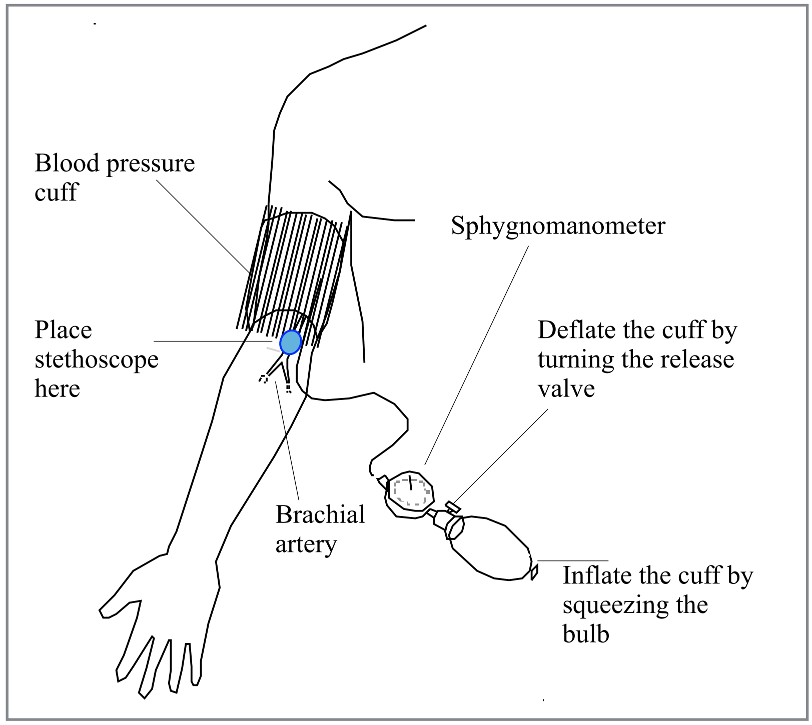
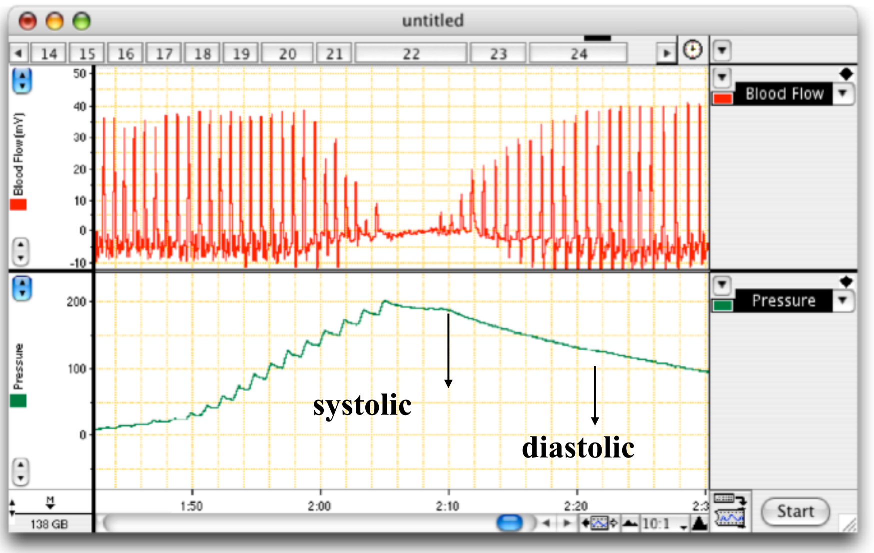


Figure 2. Placement of the cuff and stethoscope.

Procedure

1. Place the blood pressure cuff around the upper portion of the arm of the volunteer, between the elbow and the shoulder.
2. Place the bell of the stethoscope over the brachial artery, as shown in Figure 2. The artery lies medial to the biceps tendon, just above the elbow crease.
3. Inflate the cuff until the pressure reaches approximately 180 mmHg.
4. Slowly reduce the pressure in the cuff (~1 to 2 mmHg per second) while listening through the stethoscope for Korotkoff sounds.
5. Note the pressure value at which regular tapping sounds are first heard. This is the systolic pressure (see Figure 3).
6. Continue slowly reducing cuff pressure, listening for the cessation of sound which occurs at diastolic pressure.
7. **Completely deflate the cuff**. Work quickly — do not cut off circulation for long.



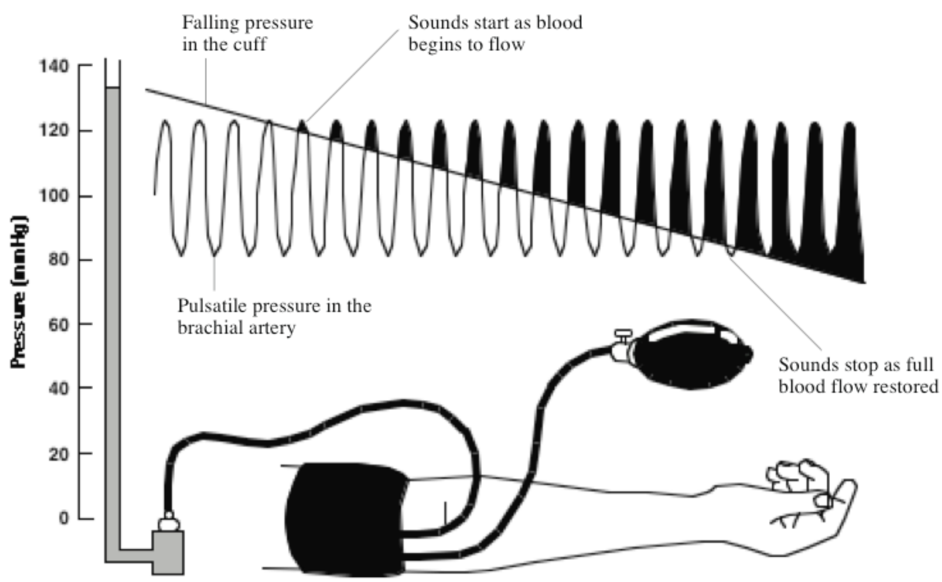


Figure 3. A graphical summary of determining blood pressure via auscultation.

8. Repeat the procedure using other volunteers until you feel confident in measuring blood pressure. Allow the volunteers one to two minutes between procedures to recover.

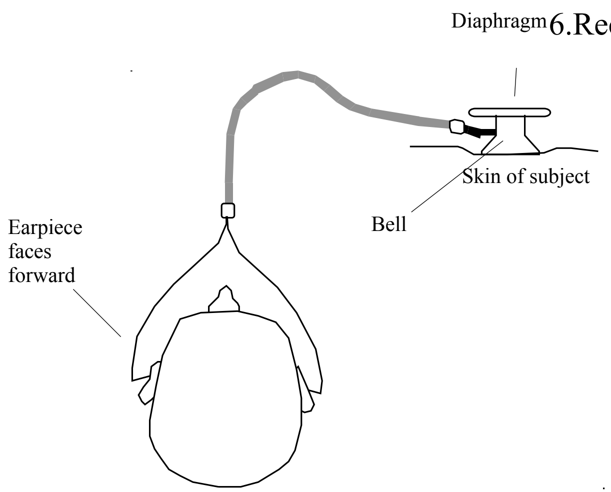
Protocol 2.2: Measuring Blood Pressure Using PowerLab

Equipment

1. Use "Blood Pressure" settings to start Chart software.
2. Setup **Finger Pulse transducer** on Input 1 (protocol 2)
3. Attach **sphygmomanometer transducer** to Input 2 (pod input). Ensure that the Luer-Lok connections on the force transducer at the sphygmomanometer are tight.

Procedure

4. Attach the transducers to the volunteer to record blood flow (using the finger pulse transducer) on the same arm as the blood pressure cuff.
5. Adjust the range of Channel 1 so that the blood flow trace occupies 1/2 - 2/3 of the full scale when the volunteer is resting with both hands in his or her lap.



6. Record the finger pulse for about ten seconds, and comment (i.e., "resting pulse"). Inflate the cuff until the pulse signal disappears at around 180-200 mmHg on the dial. Hold for a few seconds, then slowly release the pressure (Figure 4). **Completely deflate the cuff.**

Figure 4. Some typical results from Exercise 2, with systolic and diastolic pressures indicated.

7. If the maximum pressure in step 3 is outside of the 180-200mmHg range, *Calibrate the sphygmomanometer:*

1. "Pressure" pull-down menu > "Units Conversion." Clear old calibration: > "Off" > "OK." The values are now in mV. Look at the chart, write down the baseline mV (=0 mmHg) and maximum mV(~200 mmHg). Return to the "Units Conversion" window and enter these values for Point 1 and Point 2 (Figure 5). Repeat if fussy.

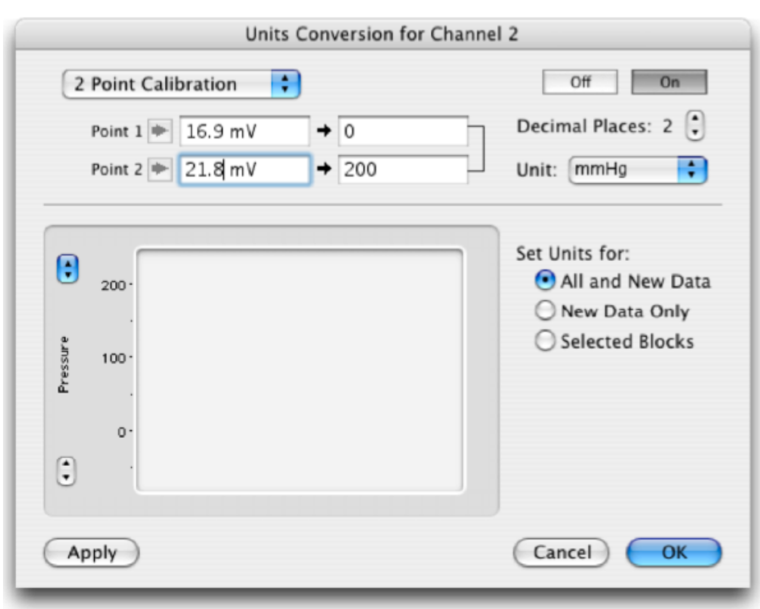


Figure 5. Units conversion window.

5. Repeat recording (step 3), but this time listening for blood flow with the stethoscope. Mark a comment when the **systolic pressure**

is first heard through the stethoscope. Mark another comment when the **diastolic pressure is reached.** Continue to deflate and record for a few seconds and then **quickly and completely deflate the blood pressure cuff.**

Notes:

1. Ensure the volunteer is relaxed and sits as still as possible to minimize signal noise.
2. ****Remember to release the pressure EACH TIME you are done taking data, if you leave it on for too long it could cause pain and injury****

   systolic **diastolic**

3. If you are unable to hear the pulse through the stethoscope, try reading the needle on the sphygmomanometer, when it starts to "bounce", this is the systolic reading, and listen carefully for the sound. When the needle stops "bouncing" this the diastolic reading. The volunteer may also be able to feel the start of the systolic readings when they start feeling the pulse and the diastolic reading when they can no longer feel the pulse. There are multiple checks!

Protocol 3: Human ECG

The equipment required for ECG measurement is:

- PowerLab with BioAmp front end connected
- Finger pulse transducer
- Three-lead Bio Amp cable & three skin electrodes
- Alcohol and cotton swabs
- Abrasive pads
- The push-button switch
- A stethoscope.

Subject and BioAmp preparation

1. The student volunteering for the experiment should remove any watch or jewelry from his or her wrists and ankles.
2. Connect the push-button switch to the BNC socket for Input 1. This is to mark events.
3. (old setup) Connect the BioAmp front end BNC connector to Input 2 on the PowerLab. (New case setup) Connect to the BioAmp connector on the Powerlab (channel 3/4)
4. Connect the finger pulse transducer to Input 3 on the PowerLab (input 2 on new unit)
5. Connect the ECG leads to Earth (green), positive (black) and negative (white), on the Bio Amp cable.
6. If alcohol swabs are available, firmly swab the skin with them in each area where electrodes will be placed (Figure 4). Lightly abrade the skin at these areas with an abrasive pad. This decreases the electrical resistance of the outer layer of skin and ensures good electrical contact.
7. Attach the ECG electrodes to the volunteer in the positions described below. Ensure good electrical contact between the electrode and the skin: use conductive gel and make sure there are no air bubbles or hair under the electrode which will reduce electrical conductivity.
8. Attach the finger pulse transducer. The volunteer is relaxed and sits as still as possible.

Attaching the electrodes

For the classical placement of electrodes for ECG, attach the positive electrode to the left wrist, the negative to the right wrist, and the ground to the right leg. If after looking at the signal in the Bio Amplifier dialog box during the first exercise you find that this does not produce a good signal, you can use the alternative method shown. (Figure 4)

The electrodes should not be placed over the major muscles of the upper arm (that is, the biceps or triceps) because muscle activity produces electrical signals that interfere with the signal recorded from the heart. Attach the electrodes on the outer side of the arm, midway between the elbow and the shoulder.

Remember to ensure that the volunteer is relaxed and sits as still as possible, arms at rest, hands in lap, to minimize any signal from movement.

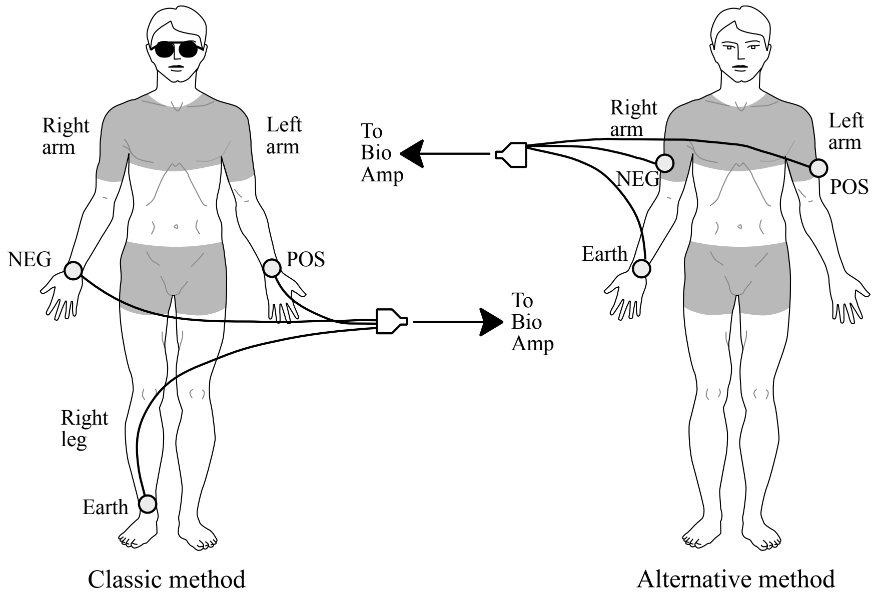


Figure 5. Connecting the electrodes to the volunteer: two alternative methods.

Software settings

Load the ECG settings file. If you are using the new setup (silver case), you will have to change the channel settings in the chart software. By default, it is set up to have the ECG on channel 2 and the finger pulse transducer on channel 3. You will have to switch this. Find the "Channel Settings" menu item, and set the ECG to channel 3 (Bioamp), and set the finger pulse and blood flow channels to channel 2 (the blood flow is a computed channel based on the finger pulse transducer — the integral of the finger pulse signal).

Troubleshooting

If you are not seeing an ECG trace, check that all three electrodes are correctly attached. Adjust the range if necessary. Try autoscale. If the signal is noisy, make sure that the volunteer is relaxed. Try the alternative electrode positions (Fig. 4).