

Experiment CP-2: Heart Sounds and the Electrocardiogram (ECG)

Background

Blood enters the arterial system from the ventricles of the heart in a pulsatile manner. However, when blood is leaving the arterial system through the capillaries, it flows in a continuous manner. Between contractions, when the heart is relaxed and blood is not being pumped into the arterial system, there is still enough pressure in the arterial system to move blood along the arteries. The pressure in the arterial system exists because the elasticity of the arteries allow them to distend and recoil and function as a pressure reservoir.

When the ventricles contract, the pressure of the blood inside the ventricles increases to close the atrioventricular valves. Further contraction increases the ventricular pressure until it exceeds the arterial pressure. At this point, when the arterial pressure is at its lowest point during the cardiac cycle (called diastolic pressure) the semilunar valves are forced open, and blood flows into the artery. Blood entering the arterial system inflates the arteries a little and increases blood pressure to a maximum, which is the systolic pressure.

In this lab you will record the ECG from a subject and listen to the characteristic “lub-dub” heart sounds. The “lub” sound occurs during the early phase of ventricular contraction and is produced by closing of the atrioventricular valves, which prevents blood flow into the atria. When the ventricles relax, the blood pressure drops below what is in the artery and the semilunar valves close, producing the “dub” sound.

Equipment Required

PC or Macintosh computer

IX-ELVIS

USB cable

Power supply

Red, black, and green ECG leads

EMN-100 Event marker

Stethoscope

Alcohol swabs

Disposable ECG electrodes

IX-ELVIS Setup

1. Place the IX-ELVIS unit on the bench, close to the computer.
2. Connect the IX-ELVIS to the computer with the supplied USB cable.
3. Insert the power plug into the rear of the IX-ELVIS and plug the transformer into the electrical outlet. Turn on the power switches on the rear and on the upper right side of the top of the unit and confirm that the LEDs are illuminated.

Start the Software

1. Click on the LabScribe icon on the Desktop, or click the Windows Start menu, click Programs and open the iWorx folder and select LabScribe.
2. When the program opens, select Load Group from the Settings menu.
3. When the dialog box appears, select ELVISNI.iwxgrp and then click OK.
4. Click on the Settings menu again and select the ECGHeartSounds-LS2 settings file from the Cardiac Physiology folder.
5. After a short time, LabScribe will appear on the computer screen as configured by the ECGHeartSounds-LS2 settings.
6. The settings used to configure the LabScribe software and the IX-ELVIS for this experiment are programmed on the Preferences Dialog window which can be viewed by selecting Preferences from the Edit menu on the LabScribe Main window.

ECG Electrodes and Event Marker Setup

1. Locate the electrode lead wires ([Figure CP-2-S1](#)), and EMN-100 event marker ([Figure CP-2-S2](#)).
2. Plug the mini-DIN connector to the EMN-100 event marker into the Channel 3 input of the IX-ELVIS ([Figure CP-2-S3](#)).
3. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets of Channel 1 of the IX-ELVIS ([Figure CP-2-3](#)).
4. Instruct the subject to remove all jewelry from their wrists and ankles.

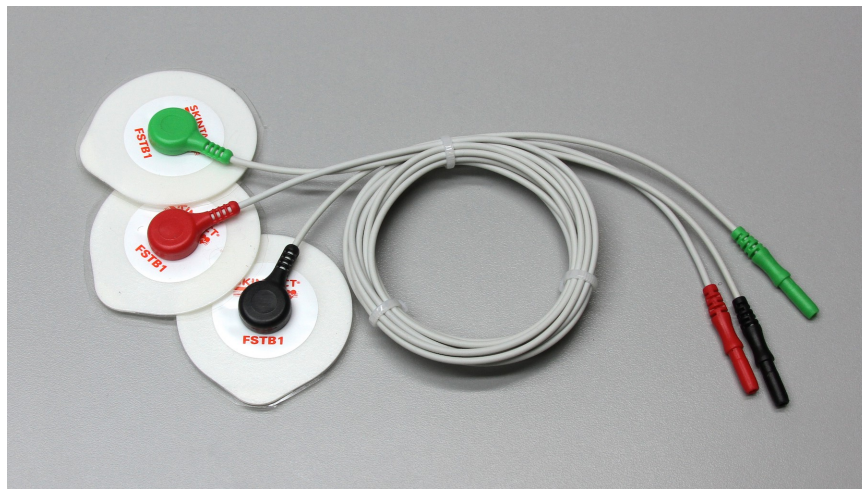


Figure CP-2-S1: The ECG electrode leads connected to disposable electrodes.



Figure CP-2-S2: The EMN-100 event marker.

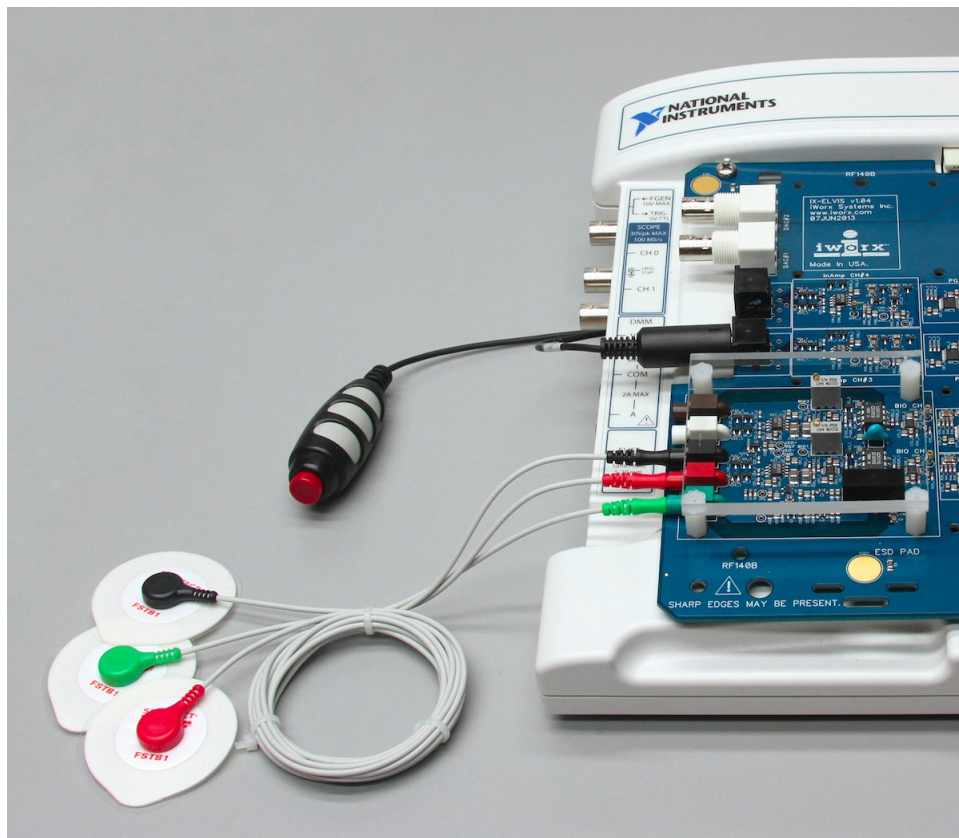


Figure CP-2-S3: The ECG leads and event marker connected to the IX-ELVIS.

5. Use an alcohol swab to clean a region of skin on the inside of the subject's right wrist. Let the area dry. Then, rough up the skin in that area with an emery board. this improves the conductivity of the electrodes.

6. Remove a disposable ECG electrode from its plastic shield, and apply the electrode to the scrubbed area on the wrist.
7. Repeat Steps 5 and 6 for the inside of the left wrist and the inside of the right ankle.
8. Snap the lead wires onto the electrodes, so that:
 - the red (+1) lead is attached to the left wrist,
 - the black (-1) lead is connected to the right wrist,
 - the green (C or ground) lead is connected to the right leg.
10. Instruct the subject to sit quietly with their hands in their lap. If the subject moves, the ECG trace will move off the top or bottom of the screen. If the subject moves any muscles in the arms or upper body, electromyograms (EMGs) from the muscles will appear on the ECG recording as noise.

Exercise 1: The ECG in a Resting Subject

Aim: To measure the ECG in a resting individual.

Procedure

1. Click on the Record button, located on the upper right side of the LabScribe Main window. The signal should begin scrolling across the screen.

Note: If the user clicks the Record button and there is no communication between the IX ELVIS and computer, an error window will appear in the center of the Main window. Make sure the IX-ELVIS is turned on and connected to the USB port of the computer. Click OK and select the Find Hardware function from the LabScribe Tools menu.

2. Click on the AutoScale button at the upper margin of the ECG channel.
 - If the signal on the ECG channel is upside down when compared to trace, click on the downward arrow to the left of the channel title and select the Invert function. The trace should now look similar to the one in the figure.
 - If a larger signal is required, the electrodes should be moved from the wrists to the skin just below each clavicle.
3. When you have a suitable trace, type "<Subject's Name> Resting ECG" in the Mark box to the right of the Mark button. Press the Enter key on the keyboard to attach the comment to the data. Record for a minute or two.
4. Click Stop to halt recording.
5. Select Save As in the File menu and type a name for the file. Choose a destination on the computer in which to save the file. Designate the file type as *.iwxdata. Click on the Save button to save the data file.

Data Analysis

1. Scroll through the recording and find a section of data with four to six good ECG cycles in succession.

2. Use the Display Time icons to adjust the Display Time of the Main window to show at least four complete ECG cycles on the Main window. Four adjacent ECG cycles can also be selected by:
 - Placing the cursors on either side of a group of four complete ECG cycles; and
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the four selected ECG cycles to the width of the Main window.
3. Click on the Analysis window icon in the toolbar ([Figure CP-2-L1](#)) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window ([Figure CP-2-L2](#)).

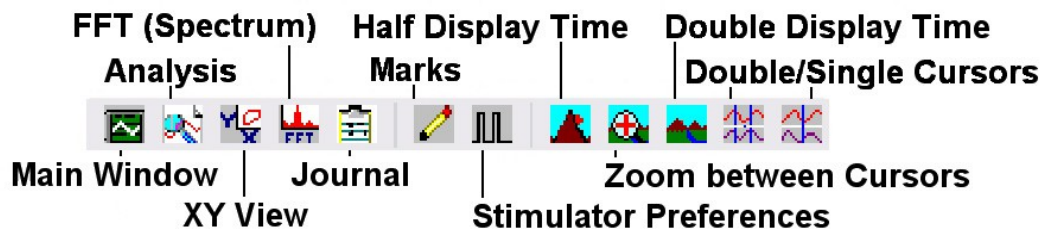


Figure CP-2-L1: The LabScribe toolbar.

4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The names of the mathematical functions used in the analysis, V2-V1 and T2-T1, appear in this table. The values for V2-V1 and T2-T1 from each channel are seen in the table across the top margin of each channel.
5. Once the cursors are placed in the correct positions for determining the amplitudes and the beat period on each ECG cycle, the values of these amplitudes and the time interval can be recorded in LabScribe by typing their names and values directly into the Journal, or on a separate data table.
6. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the parameters from the recording to the Journal. To use these functions:
 - Place the cursors at the locations used to measure the amplitudes and period of the ECG cycle.
 - Transfer the names of the mathematical functions used to determine the amplitudes and time interval to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.
 - Transfer the values for the amplitudes and beat period to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.
7. Use the mouse to click on and drag the cursors to specific points on the ECG recording to measure the following:
 - The R wave amplitude: To measure the R wave amplitude, place one cursor on the Q wave that precedes the R wave and the second cursor on the peak of the R wave. The value for V2-V1 on the ECG channel is this amplitude. Measure the amplitudes of two additional R

waves.

- The P wave amplitude: To measure the P wave amplitude, place one cursor on the baseline that precedes the P wave and the second cursor on the peak of the P wave. The value for V2-V1 on the ECG channel is this amplitude. Measure the amplitudes of two additional P waves.
- The T wave amplitude: To measure the T wave amplitude, place one cursor on the baseline that precedes a P wave and the second cursor on the peak of the T wave that is in the same cycle as that P wave. The value for V2-V1 on the ECG channel is this amplitude. Measure the amplitudes of two additional T waves.
- The beat period, which is the time interval between two adjacent R waves: To measure the beat period, place one cursor on the peak of an R wave and the second cursor on the peak of the adjacent R wave. The value for T2-T1 on the ECG channel is the beat period. Measure the beat period for two additional pairs of R waves.

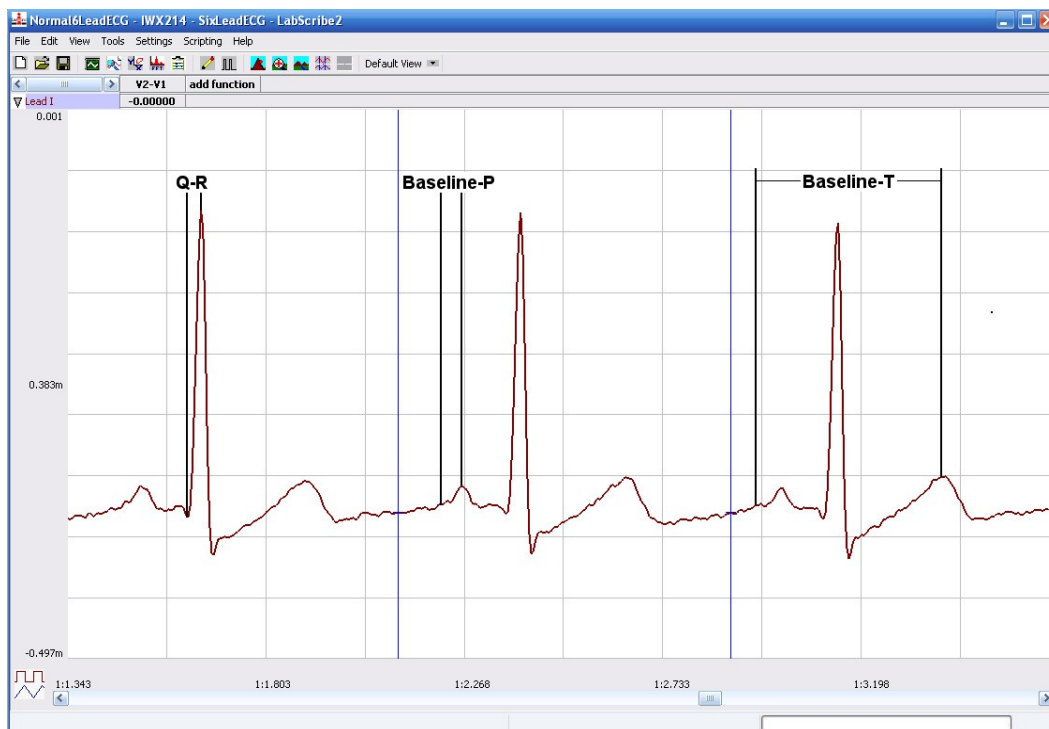


Figure CP-2-L2: ECG recording displayed in the Analysis window. Lines and labels were added to indicate the locations where cursors should be placed to measure the amplitudes of R (Q-R), P (Baseline-P), and T (Baseline-T) waves.

8. Calculate the following values and type your results into the Journal, or on a separate data sheet:
 - The average amplitudes of the P wave, the R wave, and the T wave.
 - The average beat period, in seconds/beat.

- The heart rate, which is expressed in beats per minute and calculated from the average beat period by using the following equation:

$$\text{Heart Rate (beats/minute)} = 60 \text{ seconds/minute} / \# \text{ seconds/beat}$$

Questions

1. Is the amplitude of each wave (P, QRS, T) always the same in different cardiac cycles?
2. Which wave has the largest amplitude?
3. What is the average resting heart rate of the subject?

Exercise 2: ECG Recordings from Other Subjects

Aim: To record electrocardiograms determine heart rates from other students.

Procedure

1. Trade places with your lab partner to perform this exercise. Disconnect the lead wires from the wrists and ankle of the first subject.
2. Place new ECG electrodes on another subject. Record the ECG from the second subject, as described in Exercise 1.
3. If time is available, repeat this exercise on additional subjects. At the beginning of each recording, type the name of the subject on the Marks line and click on the Marks button to identify the recording. Data from all participants will be posted on the board for discussion.

Data Analysis

Measure the amplitudes of the ECG waves and beat periods of the other subjects using the same techniques used in the analysis section of Exercise 1.

Questions

1. Do the P waves of different subjects have the same amplitude? The QRS complexes? The T waves? Why?
2. For each subject, determine the wave with the largest amplitude. Is this result the same for all individuals?
3. Is the heart rate the same for each individual?
4. What is the range of resting heart rates within the class?
5. Are there any obvious correlations between resting heart rate and gender, apparent fitness, or diet of your subjects? To determine apparent fitness, the class may want to compose a list of questions that will allow you to assign a relative fitness factor to each subject.

Exercise 3: The ECG and Heart Sounds

Aim: To study the phasing of heart sounds to the ECG.

Procedure

1. Place the head of the stethoscope on the left side of the subject's chest and listen for the heart

sounds. Move the stethoscope head to different positions until heart sounds are heard clearly. Heart sounds can also be heard by placing the stethoscope over the arteries in the neck.

2. Click on the Record button. Hold the stethoscope head on the subject's chest with one hand and the event marker in the other. Press the event marker when you hear the "lub", or first heart sound, and release it when you hear the "dub", or second heart sound.
3. After recording for twenty seconds, click Stop to halt recording.
4. Select Save in the File menu on the LabScribe window.

Data Analysis

1. Scroll through the recording and find a section of data with four to six exemplary ECG waveforms and consistent responses on the event marker channel, in succession.
2. Use the Display Time icons to adjust the Display Time of the Main window to show at least four complete ECG/heart sound cycles on the Main window. Four adjacent ECG/heart sound cycles can also be selected by:
 - Placing the cursors on either side of a group of four complete ECG/heart sound cycles; and
 - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the four selected ECG/heart sound cycles to the width of the Main window.
 - Click on the Analysis window icon in the toolbar ([Figure CP-2-L1](#)) or select Analysis from the Windows menu to transfer the data displayed in the Main window to the Analysis window ([Figure CP-2-L3](#)).

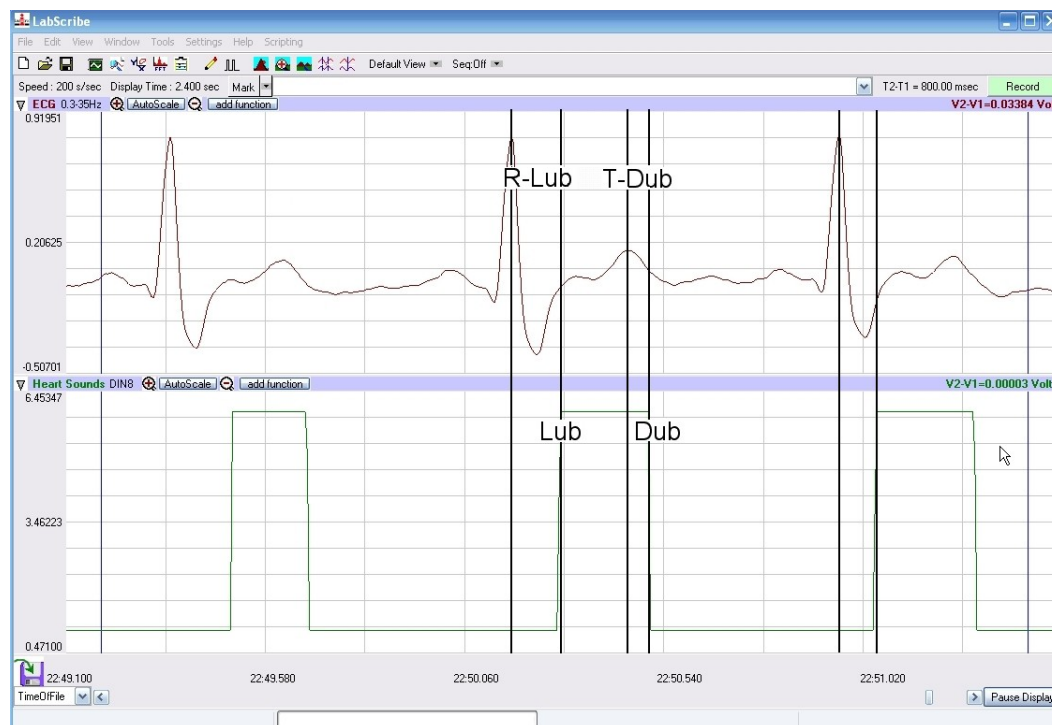


Figure CP-2-L3: ECG and event marker recordings displayed in the Analysis window. Lines and labels were added to figure to indicate the locations where cursors should be placed to measure the time intervals between the R wave and the “lub” and the T wave and the “dub”.

3. Once the cursors are placed in the correct positions for determining the time intervals on each ECG cycle, the values of these intervals can be recorded by typing their names and values directly into the Journal, or on a separate data table.
4. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the intervals from the recording to the Journal. To use these functions:
 - Place the cursors at the locations used to measure the time intervals between the ECG waves and the heart sounds.
 - Transfer the name of the mathematical function used to determine the time intervals to the Journal using the Add Title to Journal function in the ECG Channel pull-down menu.
 - Transfer the values for the time intervals to the Journal using the Add Ch. Data to Journal function in the ECG Channel pull-down menu.
5. Use the mouse to click on and drag the cursors to specific points on the ECG recording to measure the following:
 - The R-Lub Interval, which is the time interval between the peak of an R wave and the onset of the event mark. The onset of the event mark indicates the occurrence of the first heart sound or “lub”. Record the value for T2-T1 of either channel. Measure this time interval for two additional ECG cycles.
 - The T-Dub Interval, which is the time interval between the peak of a T wave and the offset of the event mark. The offset of the event mark indicates the occurrence of the second heart sound or “dub”. Record the value for T2-T1 of either channel. Measure this time interval for two additional ECG cycles.
6. Calculate the following values and type your results into the Journal
 - The average R-Lub interval.
 - The average T-Dub interval.

Questions

1. Why does the lub sound occur around the peak of the R wave?
2. Is the time delay between the R wave and the lub sound always the same? Explain why the time delay is or is not the same.
3. Why does the dub sound occur around the peak of the T wave?
4. Is the time delay between the T wave and the dub sound always the same? Explain why the time delay is or is not the same.