

Experiment HH-2: The Electrocardiogram and Heart Sounds

Note – this lab uses a manual or electronic stethoscope so that students can gain an understanding for using an external stethoscope for listening to the heart. If you would like to use the Heart Sounds microphone instead – please refer to Lab HH-8 “Auscultation”.

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

iWire-B3G ECG cable and electrode lead wires

EM-220 Event marker

Stethoscope

Alcohol swabs

Disposable ECG electrodes

Note – You must connect the iWire-B3G prior to turning on the IXTA.

ECG Cable and Event Marker Setup

1. Locate the iWire-B3G ECG cable and electrode lead wires and EM-220 event marker.
2. Plug the DIN8 connector to the EM-220 event marker into Channel EM1 on the back of the IXTA.
3. Insert the connector on the end of the iWire-B3G ECG cable into the iWire 1 input on the front of the IXTA.
4. Insert the connectors on the red, black, and green electrode lead wires into the matching sockets of the ECG cable.
5. Instruct the subject to remove all jewelry from their wrists and ankles. Another option is to use the area just under each clavicle which will give a better recording.
6. Use an alcohol swab to clean a region of skin on the inside of the subject's right wrist/clavicle. Let the area dry. Then, rough up the skin in that area with an emery board. This improves the conductivity of the electrodes.
7. Remove a disposable ECG electrode from its plastic shield, and apply the electrode to the scrubbed area on the wrist.
8. Repeat Steps 6 and 7 for the inside of the left wrist/clavicle and the inside of the right ankle.
9. Snap the lead wires onto the electrodes, so that:
 - the red (+1) lead is attached to the left wrist or under the left clavicle,
 - the black (-1) lead is connected to the right wrist or under the right clavicle,
 - the green (C or ground) lead is connected to the right leg or on the abdomen.

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.



Figure HH-2-S1: The ECG cable and event marker connected to an IXTA.

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Exercise 1: The ECG in a Resting Subject

Aim: To measure the ECG in a resting individual.

Approximate Time: 15 minutes

Procedure

1. Click on the Record button. The signal should begin scrolling across the screen.
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.
3. When you have a suitable trace, type **Resting ECG** in the Mark box. Click the mark button 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, type a name for the file. Click on the Save button to save the data file.

Data Analysis

1. Scroll through the recording and find a section of data with ten good ECG cycles in succession.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the complete ECG cycles on the Main window.
3. Data can be collected from the Main window or the Analysis window. If you choose to use the Analysis window, click on the Analysis window icon in the toolbar.
4. The mathematical functions, V2-V1 and T2-T1 should appear on screen. Values for V2-V1 and T2-T1 on each channel are seen in the table across the top margin of each channel, or to the right of each graph.

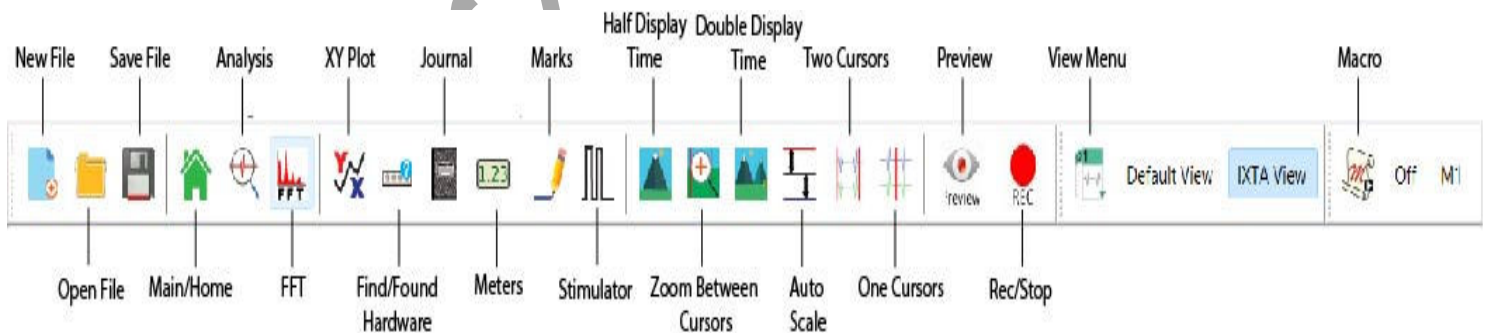


Figure HH-2-L1: The LabScribe toolbar.

4. 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.
 - 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 (measure at least 5 ECG cycles):
 - 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.
 - 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.
 - 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.
 - 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.

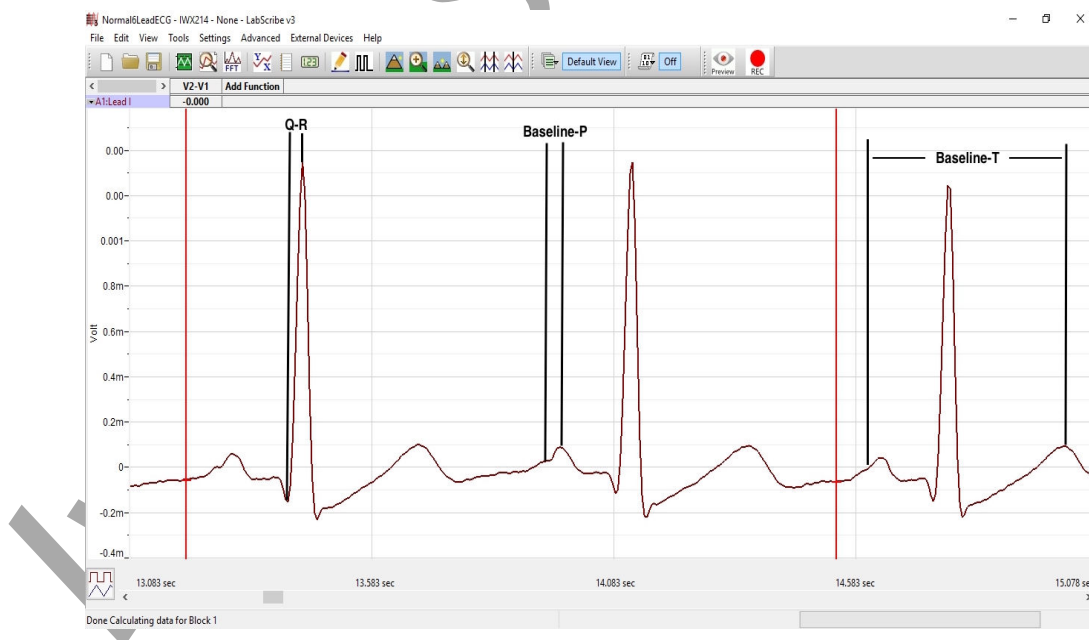


Figure HH-2-L2: ECG recording displayed in the Analysis window. Lines and labels were added to indicate the locations where cursors should be placed to measure the amplitudes of R (Q-R), P (Baseline-P), and T (Baseline-T) waves.

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:

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

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 measure heart rate from all students.

Approximate Time: 15 minutes per subject

Procedure

1. 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. Repeat this exercise on additional subjects, within the time limits of the lab period. 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 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.

Approximate Time: 15 minutes

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. Click 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 10 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 the complete ECG/heart sound cycles on the Main window.

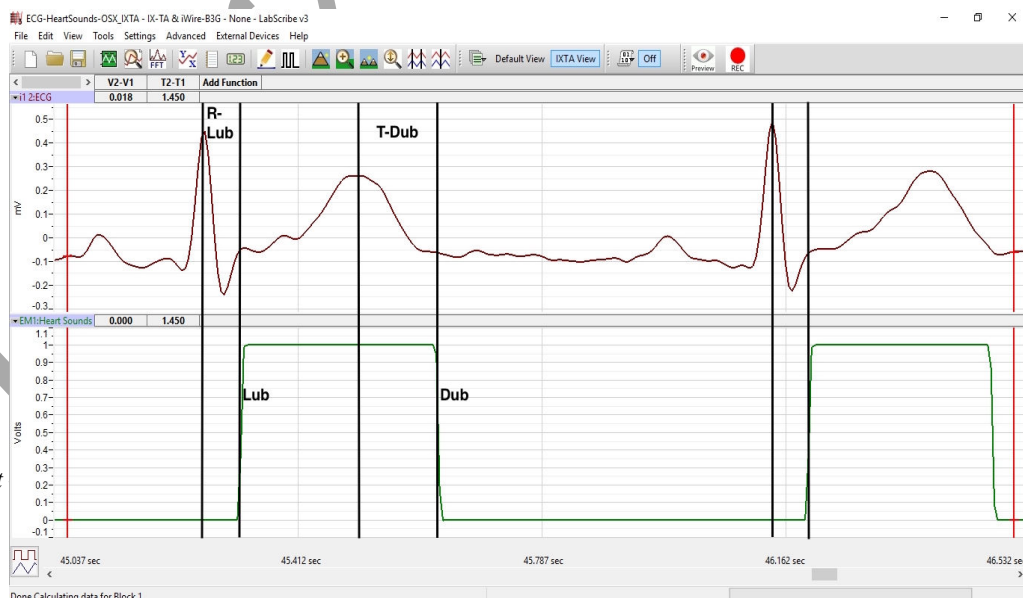


Figure HH-2-L3: ECG and event marker recordings displayed in the Analysis window. Lines and labels were added to figure to indicate the locations where cursors should be placed to measure the time intervals between the R-wave and the “lub” and the T-wave and the “dub”.

3. Use the same techniques for measuring the values as in Exercise 1.
 - 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.

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