Experiment HC-4: Pulse Contour Analysis

Equipment Required

PC or Mac Computer

IXTA data acquisition unit

USB cable

IXTA power supply

PPG-320 Pulse plethysmograph

BP-220 Non-invasive blood pressure transducer

BT-220 Black tygon tubing with Luer connectors

Meter stick

Blood Pressure and Pulse Transducers Setup

Automated Blood Pressure and Pulse Transducer Setup

1. Find the automatic blood pressure monitor and blood pressure cuff.
2. Slide the gray connector on the tubing of the BP cuff into the port on the left side of the BP monitor.
3. To turn on the BP monitor using the On/Off switch on the right side of the monitor.
4. Plug the pulse sensor into the PT port.

Figure HC-4-S1: The BP-220A Automated non-invasive blood pressure transducer.

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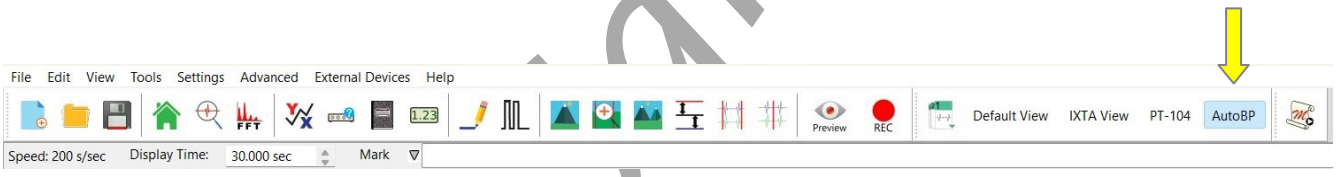
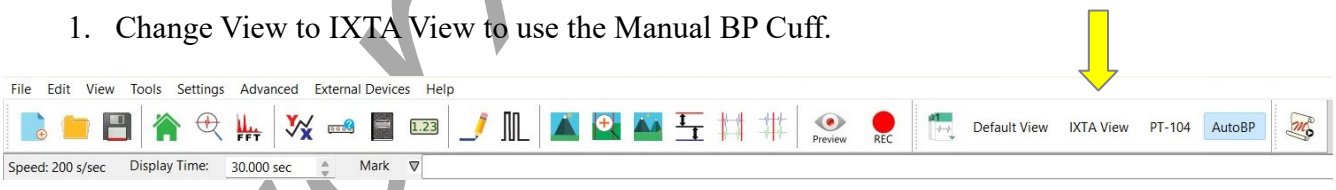
Figure HC-4-S2: The PT sensor plugged into the PT port of the IX-TA-ROAM



Manual Blood Pressure and Pulse Transducer Setup

1. Change View to IXTA View to use the Manual BP Cuff.



2. Locate the BP-220 non-invasive blood pressure (NIBP) transducer and PPG-320 pulse plethysmograph.

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Figure HC-1-S3: The BP-220 manual non-invasive blood pressure transducer.

2. Plug the connector of the PPG-320 into the PT port.
3. Plug the tubing connector of the BP-220 into the channel labeled A2.
4. Calibrate the BP-220 and then put it aside until it is needed in Exercise 1.

Figure HC-4-S4: The PPG-320 pulse sensor and the BP-220 blood pressure cuff connected to the TA.

Sample Lab

Calibration of the Manual Non-Invasive Blood Pressure Transducer

Procedure

1. Lay the cuff of the BP-220 flat on the lab table.
2. Click on the Record button. Record 10 seconds of data.
3. Click on the AutoScale All button.
4. On the Blood Pressure channel, move one cursor to the left side of the screen and the other to the right, spanning about 6-8 seconds of data.
5. Click V2-V1 on the right side of the Blood Pressure channel and click Set Offset.
6. When the Set Offset window opens, set the values and radio buttons as in the image below.
   - Put a check mark in the box next to Apply the calculated offset for this block to all blocks. Set the Mean Value between Cursors to: "0" in the box at the top. Click on the OK button in the lower right corner.
7. Click OK. Click Save As in the File menu and save your data file.

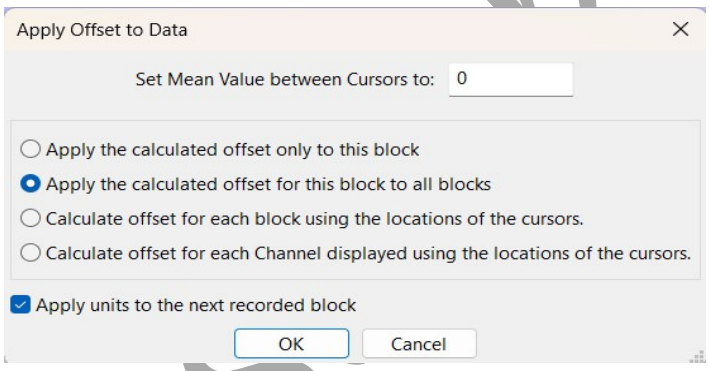

Figure HC-4-S5: The Units Offset dialogue window with the mean values set to "0".

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Experiment HC-4: Pulse Contour Analysis

Exercise 1: Arterial Stiffness

Aim: To determine the Student Stiffness Index (SSI) of the subject's major arteries.

Approximate Time: 15 minutes

Procedure

1. Make sure the subject's hands and arms are warm to promote good peripheral circulation. The subject should be resting in the supine position for at least one minute before a recording is made. He or she should also remain motionless throughout the recording.
2. Click on the Record button. Then, click on the AutoScale buttons at the upper margin of the Pulse and Pulse Integral channels. Your recording should look like the figure below.
    - If the signal on the Pulse channel is upside down when compared to the trace, click on the downward arrow to the left of the channel title and select the Invert function.
    - If the pulse signal is small or noisy, adjust the tension on the strap holding the pulse sensor to the finger.

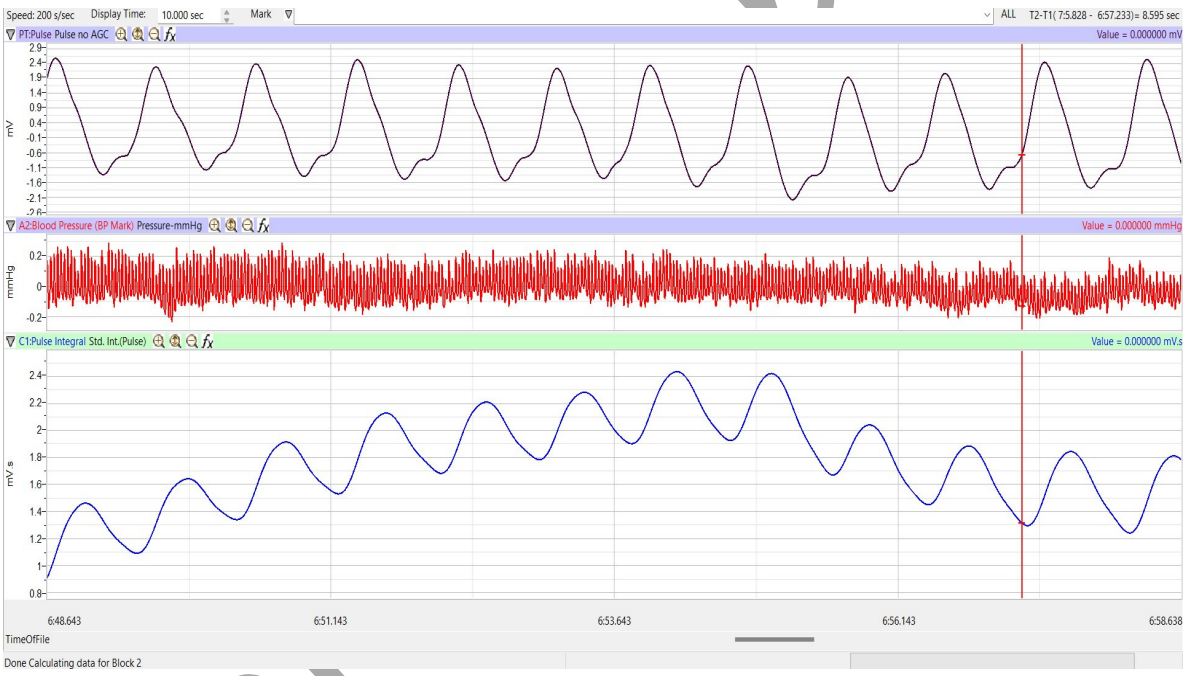

Figure HC-4-L10: The pulse and pulse integral of a resting subject displayed in the Main window.

4. When you have a suitable trace, type **Resting** in the Mark box. Click the mark button to attach the comment to the data. Record for one minute.
5. Click Stop to halt recording. Select Save in the File menu.

Workbook Lab

Data Analysis

1. Scroll through the recording and find a section of data with ten exemplary pulse/pulse integral cycles in succession.
2. Use the Display Time icons to adjust the Display Time of the Main window to show at least five to ten complete pulse/pulse integral 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.
5. 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:
    - Transfer the name of the mathematical function used to determine the blood pressure to the Journal using the Add Title to Journal function in the Pulse Integral Channel pull-down menu.
    - Transfer the value for the blood pressure to the Journal using the Add Ch. Data to Journal function in the Pulse Integral Channel pull-down menu.
6. Use the mouse to click on and drag the cursors to specific points on the pulse integral cycle to measure the reflection time of the pulse wave. Place one cursor on the systolic peak of the first pulse integral and the second cursor on the inclination point or peak of the diastolic component of the pulse integral. The value for T2-T1 is the reflection time. Record the value in the Journal using the one of the techniques described in Step 4 and 5.
7. Measure the reflection time for at least three additional pulse integral cycles. Record these values in the Journal.
8. Determine the mean reflection time for the pulse integral cycles that were measured. Enter this mean in the Journal.
9. Use a meter stick to measure the height of the subject in meters (m). Enter this value in the Journal.
10. Select Save to save the data.
11. Calculate the Student Stiffness Index (SSI) by dividing the height of the subject by mean reflection time:

12. SSI (m/sec) = Height (m)/Mean Reflection Time (sec)

13.

- Enter the Student Stiffness Index (SSI) for each subject in the Journal and Table 1.

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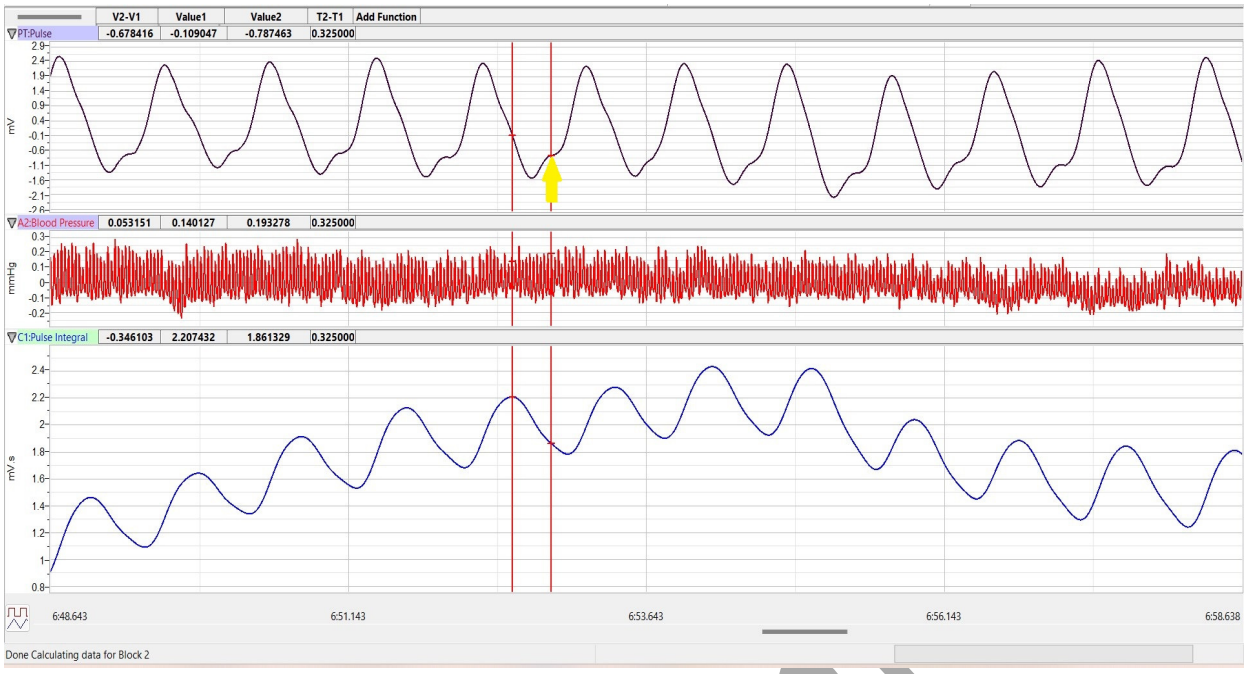

Figure HC-4-L2: The pulse and the pulse integral from a hypertensive subject displayed in the Analysis window. The cursors are at positions on the Pulse Integral channel to measure the reflection time (T2-T1).

Exercise 2: Vascular Tone

Aim: To determine the Student Reflection Index (SRI), the indicator of vascular tone in the subject's large vessels.

Approximate Time: 15 minutes

Procedure

Use the same data recorded in Exercise 1 to complete Exercise 2 and determine the Student Reflection Index.

Analysis

1. Use the same section of data that was used to determine the Student Stiffness Index (SSI) in Exercise 1.
2. Display the selected data from the Pulse Integral channel as it was done in Exercise 1.
3. Use the mouse to click on and drag the cursors to specific points on the Pulse Integral channel to measure:
    - Relative amplitude of the systolic wave. Place one cursor at the minimum value before the first pulse integral wave and the second cursor on the peak of the systolic component on the same pulse integral wave. The value for V2-V1 on the Pulse Integral channel is the relative amplitude of the systolic component.

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- Relative amplitude of the diastolic wave. On the same pulse integral wave, move the second cursor from the peak of the systolic component to the peak or inclination point of the diastolic component. Now, the value for V2-V1 on the Pulse Integral channel is the relative amplitude of the diastolic component.

4. Enter the values for the relative amplitudes of the systolic and diastolic waves into the Journal.

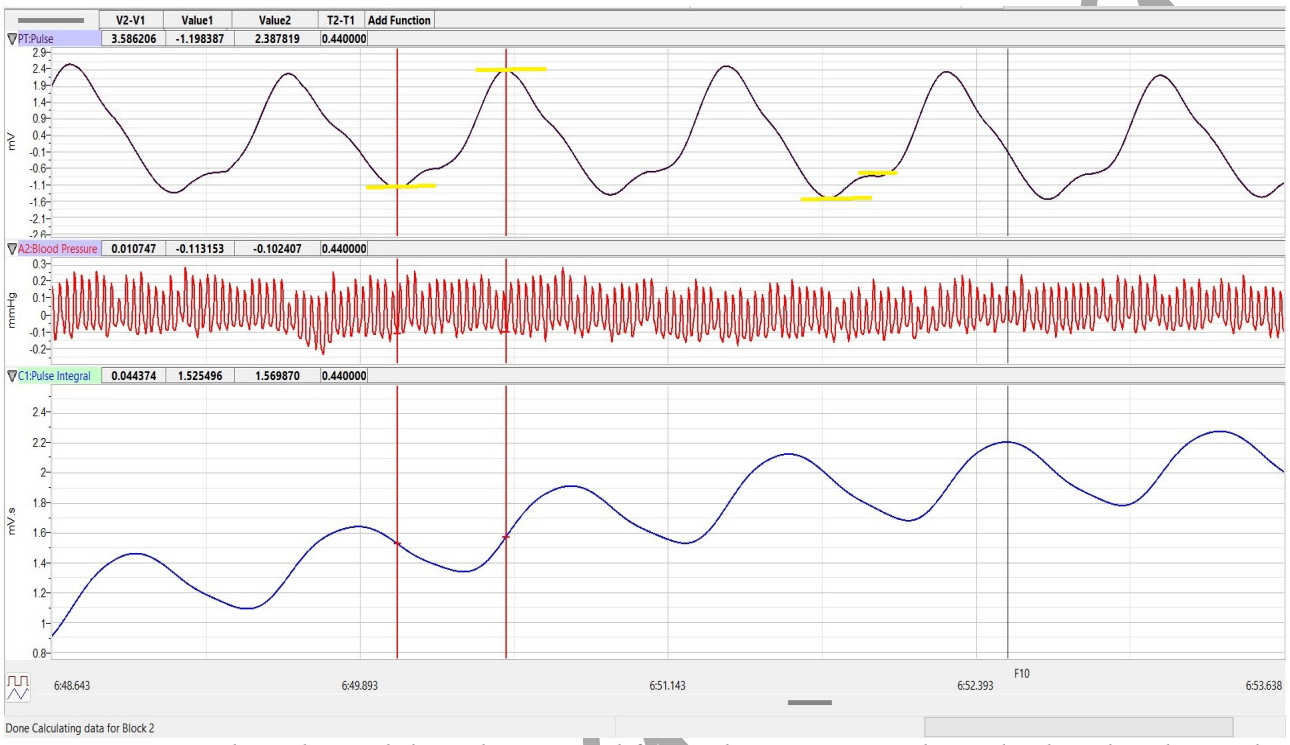

Figure HC-4-L3: The pulse and the pulse integral from a hypertensive subject displayed in the Analysis window. The wave on the left shows the positions of the cursors used to measure the relative systolic amplitude; the wave on the right shows the positions of the cursors used to measure the relative diastolic amplitude.

5. Repeat Steps 4, and 5 for at least three additional pulse integral waves that are displayed on the Analysis window.
6. Select Save to save the data.
7. Calculate the mean relative amplitudes of the diastolic and systolic waves of the pulse integral waves. Enter these means in the Journal.
8. Calculate the Student Reflection Index (SRI) by dividing the mean relative amplitude of the diastolic peak by the mean relative amplitude of the systolic peak:

$$\text{SRI(\%)} = \frac{\text{Mean Diastolic Amplitude} \times 100}{\text{Mean Systolic Amplitude}}$$

9. Enter the Student Reflection Index (SRI) for each subject in the Journal and Table HC-4-L1.

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Exercise 3: Blood Pressures

Aim: To determine if the subject is hypotensive, normotensive, prehypertensive, or hypertensive.

Approximate Time: 15 minutes

Procedure

1. Place the blood pressure cuff around the upper portion of the left arm, just above the elbow. Place the pulse sensor on the volar surface (where the fingerprints are located) of the distal segment of the left middle finger or thumb. Wrap the Velcro strap around the end of the finger to attach the unit firmly in place.
2. The subject should be resting in the supine position for at least five minutes before taking their blood pressure.
3. At the end of the rest period, click on the Record button to begin recording the subject's pulse, pulse integral, and the blood pressure.
4. Inflate the blood pressure cuff until the finger pulse wave on the Pulse channel disappears approximately 180 mmHg.
5. Once the pulse wave disappears, release the cuff pressure at the rate of ~10 mmHg/second. Continue to release the pressure in the cuff until all it is completely deflated.
6. If listening with a stethoscope, also click the mark button when you hear the Korotkoff sounds and again when they disappear.
7. Click the Stop button. Remove the blood pressure cuff and the pulse plethymograph from the subject. The subject should flex and extend their fingers to encourage blood circulation.
8. Select Save in the File menu.

Data Analysis

1. Scroll through the recording and find the section of data recorded while the pressure in the cuff was occluding the pulse.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the pulse, pulse integral and the pressure in the cuff from the occlusion of the artery to the pressure in the cuff being 0 mmHg.
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.

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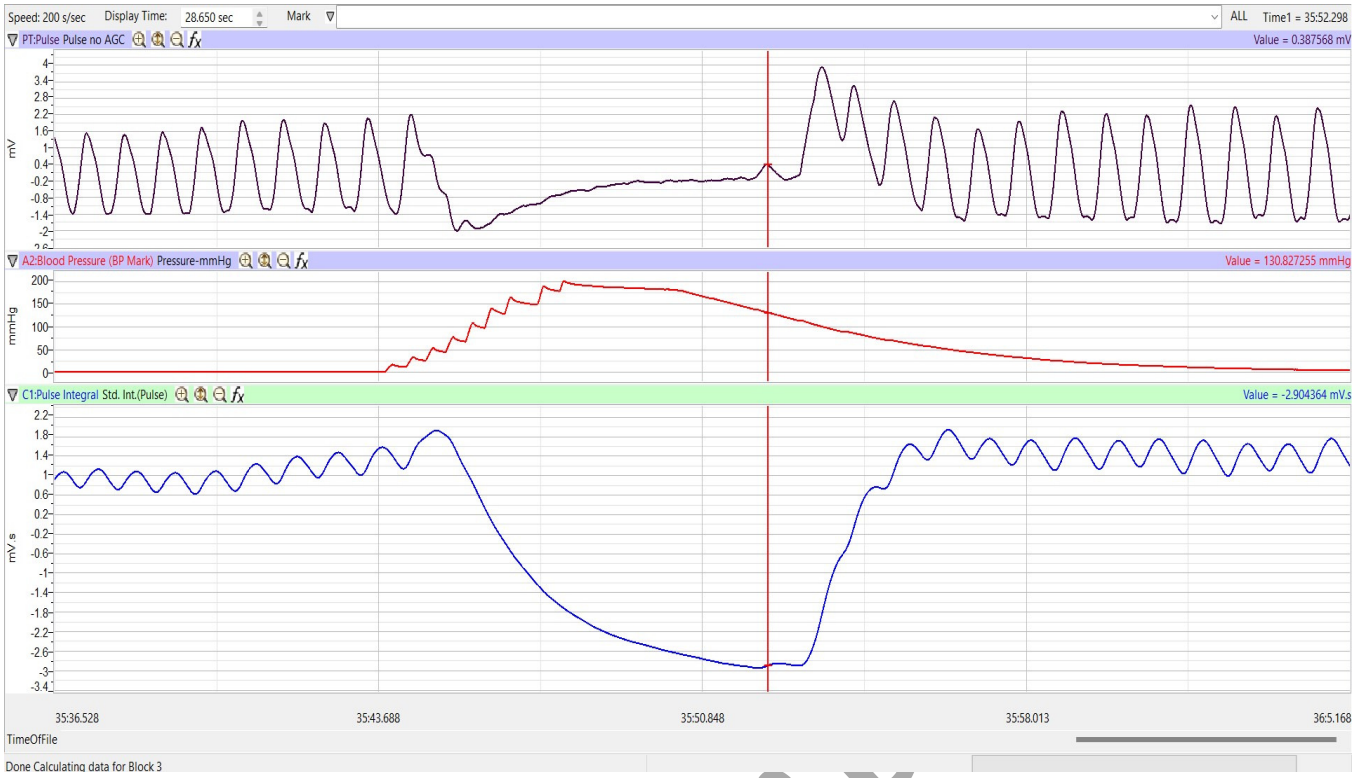

Figure HC-4-L4: The pulse wave, the pressure in the cuff, and the pulse integral recorded before, during, and after the occlusion of the brachial artery. Pulses disappeared as the pressure in the cuff exceeded the pressure in the artery.

NOTE: If using the Automated BP cuff, you will not see a blood pressure recording on the LabScribe screen. Read and record the values directly from the BP sensor.

5. Once the cursors are placed in the correct positions for determining the blood pressures, the values for the blood pressures can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the Journal.
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 cuff pressures from the Blood Pressure channel.
    - Transfer the name of the mathematical function used to determine the blood pressure to the Journal using the Add Title to Journal function in the Blood Pressure Channel pull-down menu.
    - Transfer the value for the blood pressure to the Journal using the Add Ch. Data to Journal function in the Blood Pressure Channel pull-down menu.

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7. Once the cursors are placed in the correct positions for determining the systolic, diastolic, and pulse pressures, record the values for these pressures in the Journal using the one of the techniques described in Steps 5 or 6.
8. Use the single cursor mode in the Main window, use the mouse to click on and drag the cursor to specific points on the pulse and blood pressure recording to measure the following:
    - Systolic blood pressure. To determine the subject's systolic blood pressure, place the cursor on the first of the smallest pulse waves that reappear after the pressure from the cuff is released. Value on the Blood Pressure channel is the subject's systolic blood pressure. Enter this pressure in Table 1.
    - Diastolic blood pressure. To determine the subject's diastolic blood pressure, more the cursor to the first of the largest pulse waves that reappear as the pressure from the cuff is released. Value on the Blood Pressure channel is the subject's diastolic blood pressure. Enter this pressure in the table.
    - Pulse pressure, which is the difference between the systolic and diastolic pressures. To measure the pulse pressure, switch to Double cursors and position the cursors the same as above. The value for V2-V1 on the Blood Pressure channel is the subject's pulse pressure. Enter this pressure in the table.
9. Divide the subject's diastolic blood pressure by their systolic blood pressure. Enter this ratio into the Journal and in the data table.
10. Determine the subject's blood pressure class from Table 2. List it in Table 1.

Questions

1. Does the Student Reflection Index (SRI) of the subject correlate to their blood pressure?
2. Does the Student Stiffness Index (SSI) of the subject correlate to their age?
3. Is there a correlation between the Student Reflection Index (SRI) and the Student Stiffness Index (SSI)?
4. To which parameter in the table does the pulse pressure correlate?
5. To which parameter in the table does the diastolic/systolic ratio correlate?
6. Divide the subjects into groups based on age (11-19, 20-29, 30-39, and so on). Compare the average Student Stiffness Index (SSI) of each age group to the other groups. What is the trend?
7. Compare the average Student Reflection Index (SRI) of each age group to the other groups. What is the trend?

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Table HC-4-L1: Resting Blood Pressures

Subject	Age	Student Stiffness Index (SSI)	Student Reflection Index (SRI)	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)	Pulse Pressure (mmHg)	Diastolic/ Systolic	Blood Pressure Class

Table HC-4-L2: Classification of Blood Pressure Levels According to JNC VI (The Sixth Report of the Joint National Committee on High Blood Pressure).

Class	Systolic Pressure (mmHg)	Diastolic Pressure (mmHg)
Hypotensive	Below 90	Below 60
Optimal	Below 120	Below 80
Normal	Below 130	Below 85
Prehypertensive	130-139	85-89
Hypertensive Stage 1	140-159	90-99
Hypertensive Stage 2	160-179	100-110
Hypertensive Stage 3	180 and above	110 and above

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