Experiment BI-11: Vascular Compliance

Part 1 – Peristaltic Pump

Equipment Required

PC or Mac Computer

TA-ROAM recorder, USB cable, power supply

BP-100 Pressure Sensor and C-DIN-EXT extension cord

BP-CalKit

Peristaltic Pump with (2) 1/8’’ Male luer connectors, and 5VDC power supply

~ 2 ft Tygon tubing

(2) Female luer connectors for each test tubing diameter (1/8’’ and ¼’’)

(1) 1/8’’ Male luer connectors

(1) 1/8’’ Female luer connectors

BP-100 Setup

1. Connect the BP-100 to Channel A5 on the TA-ROAM.
2. Calibrate the BP-100 using the instructions below.

Figure BI-11-S1: BP-100 connected to input A5 on the TA-ROAM.

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Calibration Instructions

1. Remove the white cap (male end) on the BP-100. Keep the blue cap connected (female end).

2. Connect the BP-CalKit to the Male end of the BP-100.

3. Click Record.

4. Pressurize the manometer to 100 mmHg.

5. Enter a mark in the record to indicate 100 mmHg.

6. Pressurize the manometer to 200 mmHg.

7. Enter a mark in the record to indicate 200 mmHg.

8. Open the valve on the manometer to release the pressure back to zero.

9. Position the first red cursor on the 100 mmHg mark.

10. Position the second cursor on the 200 mmHg mark.

11. Right click on the pressure channel. Select: Units – Simple.

12. Select 2 point calibration from the Units Conversion dialog. Notice that the voltages from the positions of the cursors are automatically entered into the left side data boxes.

13. Enter the two pressures, 100 and 200, used in the calibration recording in the corresponding boxes on the right side of the conversion equations. Enter the name of the units, mmHg, in the box below the pressures.

14. Put a check mark in the box next to Apply Units to all blocks.

15. Click on the OK button in the lower right corner of the window to activate the units conversion.

16. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

17. Once the channel is calibrated, disconnect the BP-CalKit from the BP-100.

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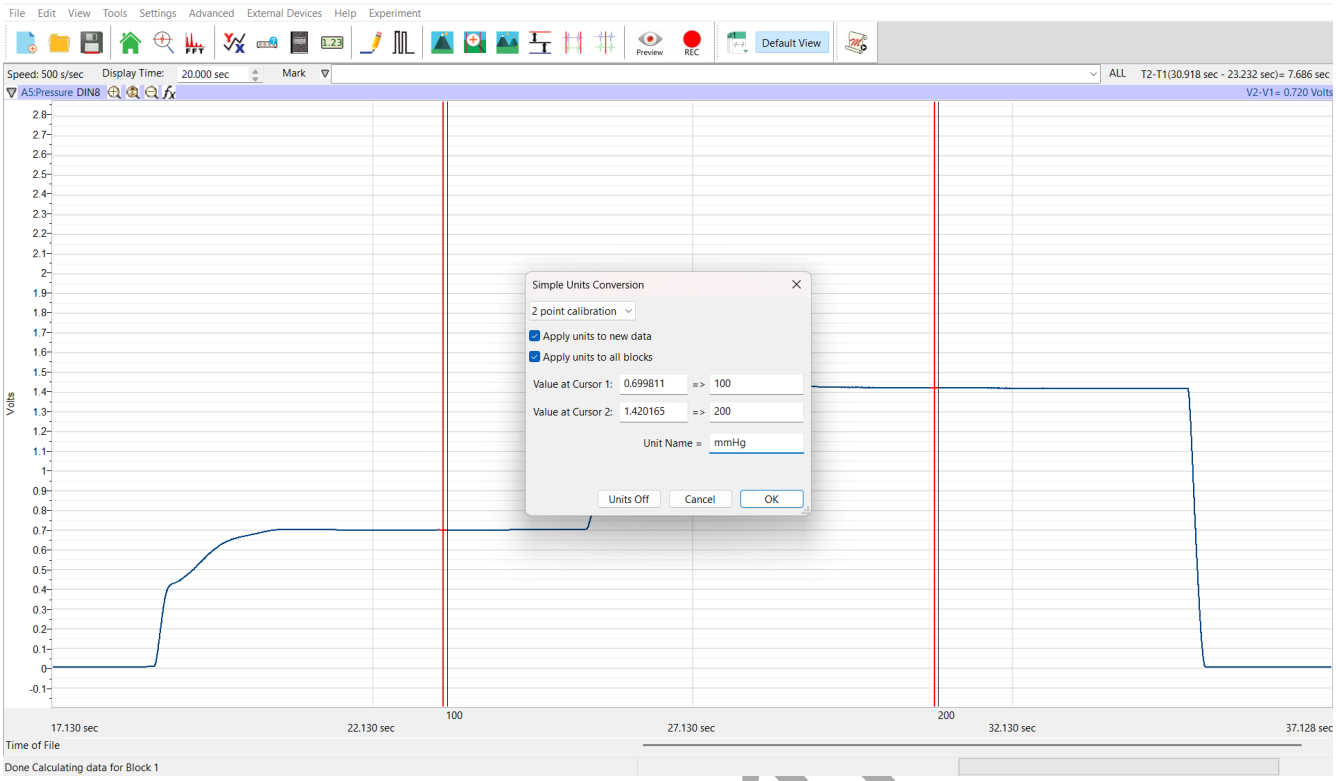

Figure BI-11-S2: The simple units calibration dialog window.

Peristaltic Pump Setup

Refer to the lab instructions for step-by-step test peristaltic pump setup.

Figure BI-11-S3: Peristaltic pump and power switch settings.

Test Tubing Setup and System Workflow

Refer to the lab instructions for step-by-step peristaltic pump and test tubing setup.

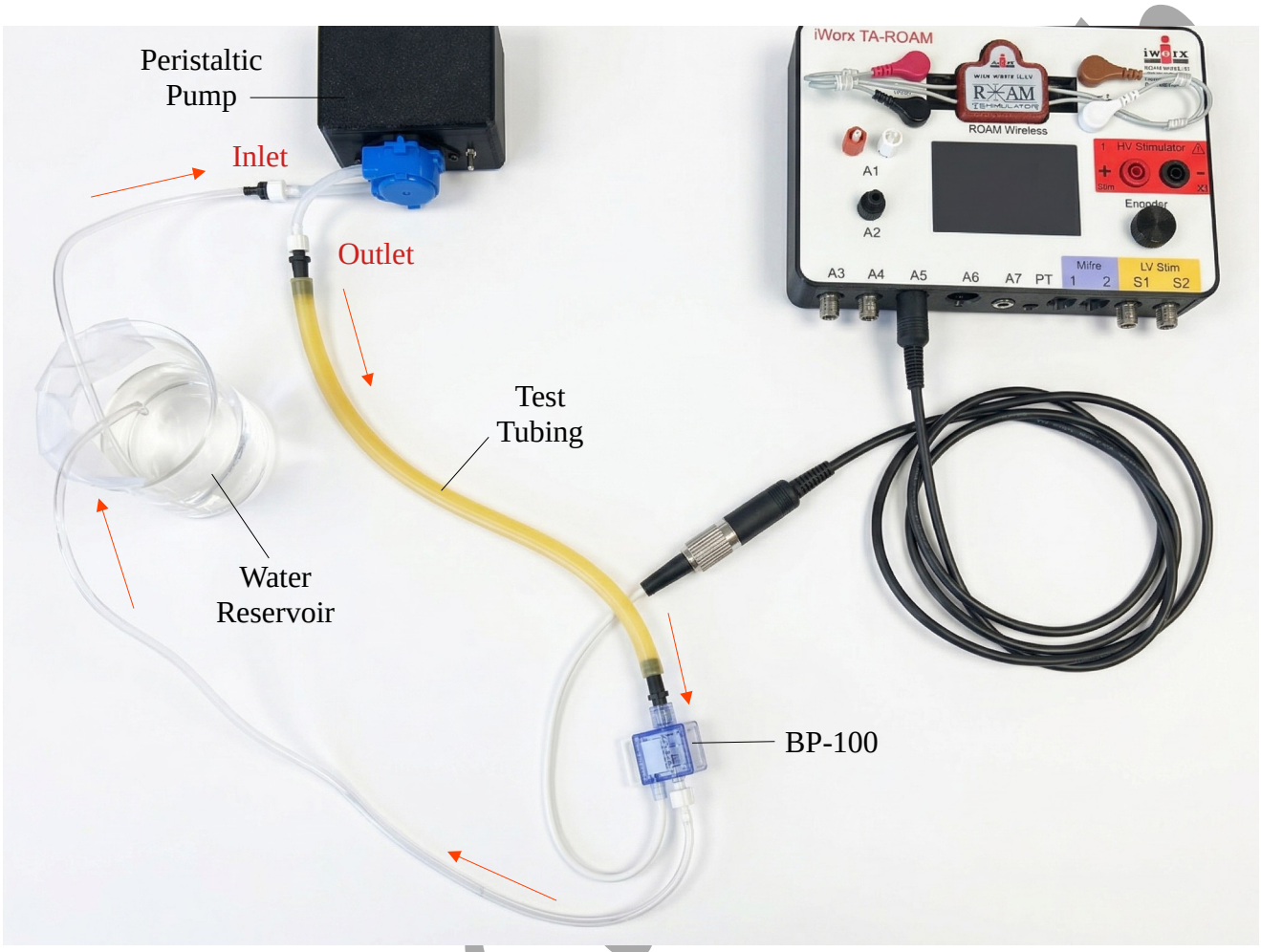

Figure BI-11-S4: System Layout: All exercises in this lab will use this identical plumbing arrangement. Water Reservoir (beaker) → 1 ft Tygon tubing (inlet) → Peristaltic Pump → Test Tubing (variable: material, diameter, length) → BP-100 Pressure Sensor → 1 ft Tygon tubing (outlet) → Return to Water Reservoir

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Complete Part 1. When Part 1 is complete, refer to the setup instructions below for Part 2.

Part 2 – Syringe

Equipment Required

PC or Mac Computer

TA-ROAM recorder, USB cable, power supply

BP-100 Pressure Sensor

BP-CalKit

1 mL syringe with syringe holder

25 mL syringe for filling up the test tubing

(2) Female Luer connectors for each test tubing diameter (1/8'' and ¼'')

Test Tubing Setup

Refer to the lab instructions for step-by-step test tubing setup.

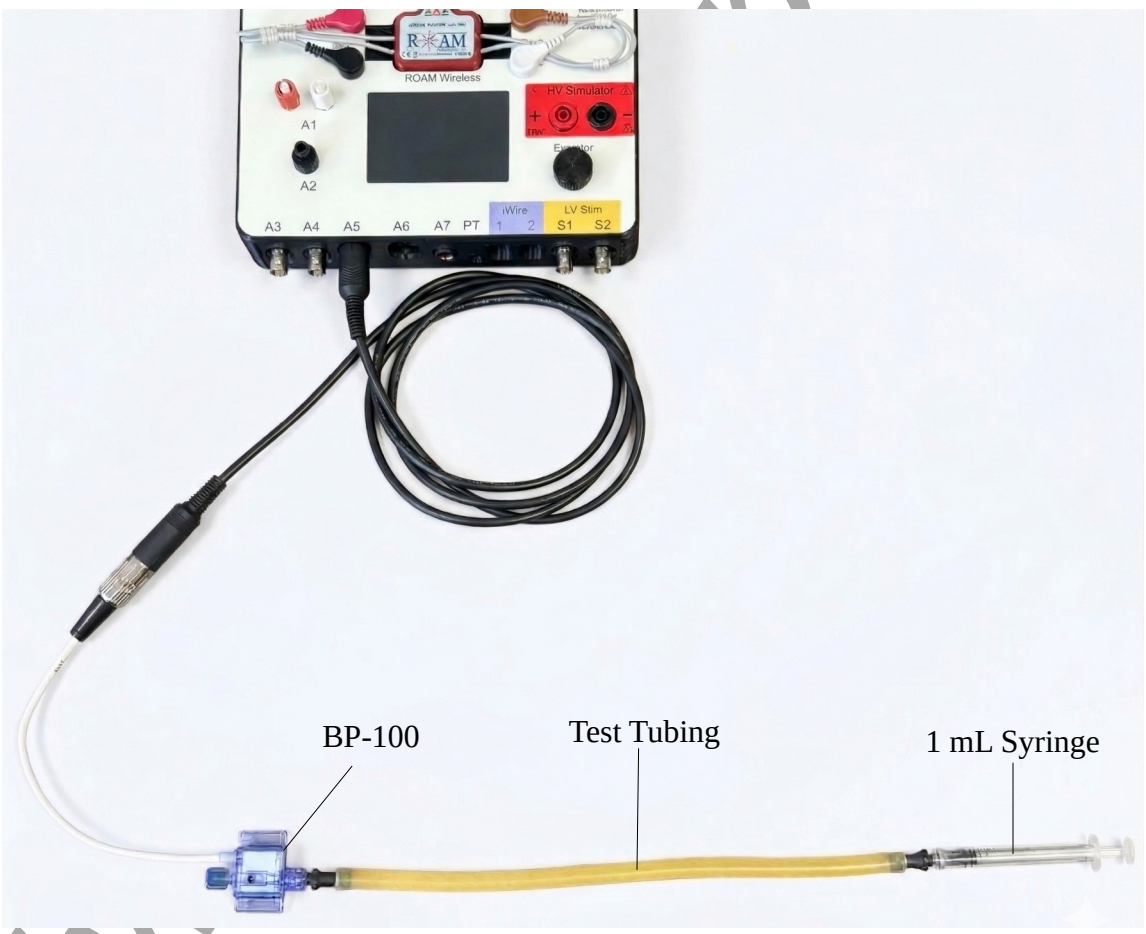

Figure BI-11-S5: TA-ROAM, BP-100, test tubing, and 1 mL syringe.

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Syringe Setup

Refer to the lab instructions for step-by-step syringe setup.

Figure BI-11-S6: Syringe holder.

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Experiment BI-11: Vascular Compliance

Part 1 – Peristaltic Pump

Exercise 1: Effect of Tubing Material (Material Stiffness)

Aim: To observe how tubing compliance affects pulsatile pressure amplitude and max–min dP/dt for different materials when driven by a peristaltic pump acting as the "heart."

Approximate Time: 30 minutes

Procedure:

System Layout: All exercises below use this identical plumbing arrangement.
Water Reservoir (beaker) → 1 ft Tygon tubing (inlet) → Peristaltic Pump → Test Tubing (variable: material, diameter, length) → BP-100 Pressure Sensor → 1 ft Tygon tubing (outlet) → Return to Water Reservoir

1. Fill a beaker (or Tupperware container) with approximately 150 mL of water to act as the water reservoir.
2. Connect 1 ft of Tygon tubing from the beaker to the lower inlet of the peristaltic pump using a female luer connector. Ensure the end stays submerged.
3. Choose a test tubing. Connect a female luer connector to each end.
4. Connect one end of the test tubing to the male luer connector (outlet) of the peristaltic pump, and the opposite end to the male connection on the BP-100.
5. Connect 1 ft of Tygon tubing from the female connection on the BP-100 to the water reservoir. Leave the tubing resting above the water line to let the system flush out all air. Tape can be used to hold the tubing above the water reservoir.
6. Flip the switch upwards on the peristaltic pump to turn it on. Prime the system so that water fills the entire loop. Remove any air bubbles by tapping or manipulating the tubing.
7. Click the red record button in LabScribe.
8. In the Mark box, type the tubing type (e.g., Latex 1/8 diameter × 12 in) and click Mark.
9. Record for ~30 seconds to capture a clear waveform.
10. Click Stop to end the recording.
11. Select Save in the File menu.
12. The recording should look like the image below.
13. Repeat Steps 1-12 for the second test tubing.

Note: *Be sure to mark each measurement reading correctly for accurate data analysis.*

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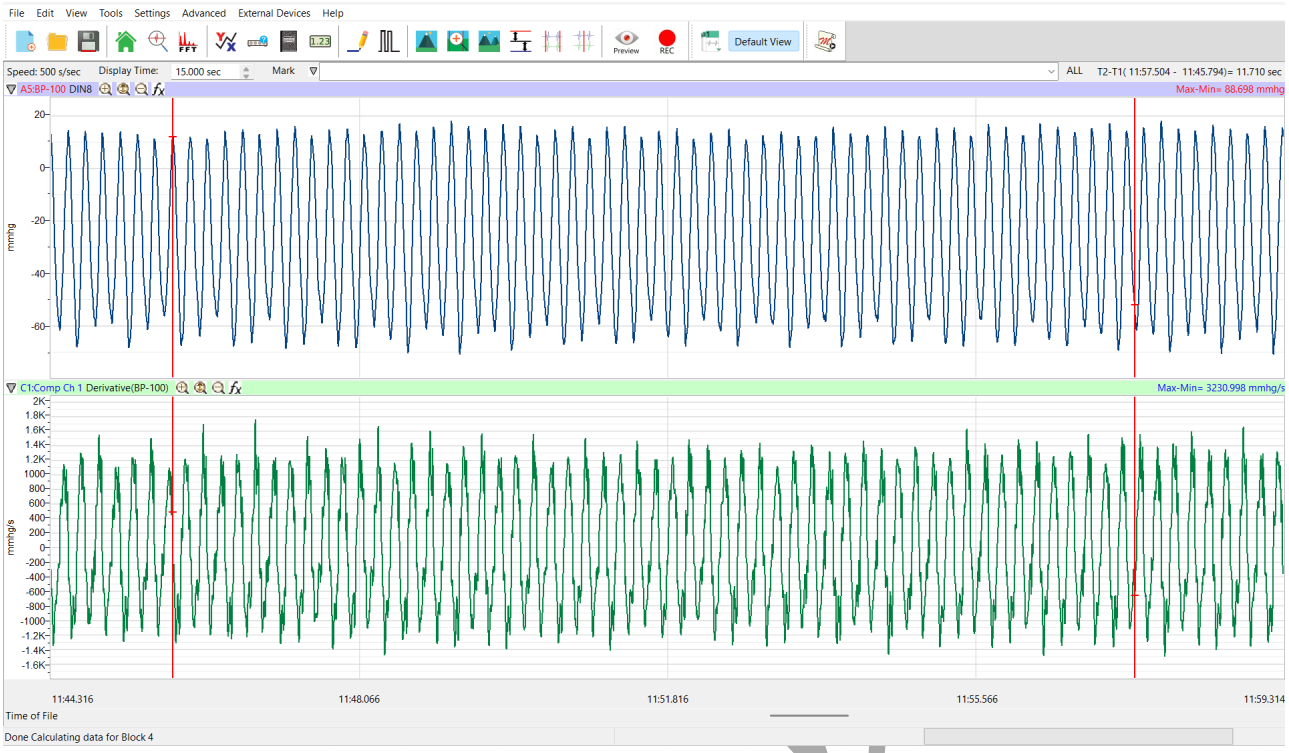

Figure BI-11-S1: Example recording showing the amplitude and dP/dt channels.

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Data Analysis

1. Use the Display Time icons on the LabScribe toolbar to position 15 seconds of the recording on the Main window. The required data can also be selected by:
    - Placing the cursors on either side of the section of data needed. Place one cursor just before the initial value mark. Place the second cursor just after the final volume value mark.
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment of data to the width of the Main window.
    - Entering 15 into the display time box and pressing Enter.
    - Marks can also be located by clicking the down arrow next to the Mark button. Click on a mark, and the recording will go to the section of the recording the mark was placed.
2. Drag the first cursor to the left of the screen, and the second cursor to the right of the screen.
3. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical function that is listed should be Max-Min. The values for this parameter from each channel is seen in the table across the top margin of each channel.
4. The values for each channel can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the Journal.
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 the Journal using the Add Title to Journal function in the pressure channel pull-down menu.
- Transfer the values to the Journal using the Add Ch. Data to Journal function in the channel pull-down menu.

6. Measure the values for the following parameters:
    - Max-Min Amplitude
    - Max-Min Derivative (dP/dt)
7. Record the values for each of these parameters in the Journal using one of the procedures described in Step 5, and in Table 1.

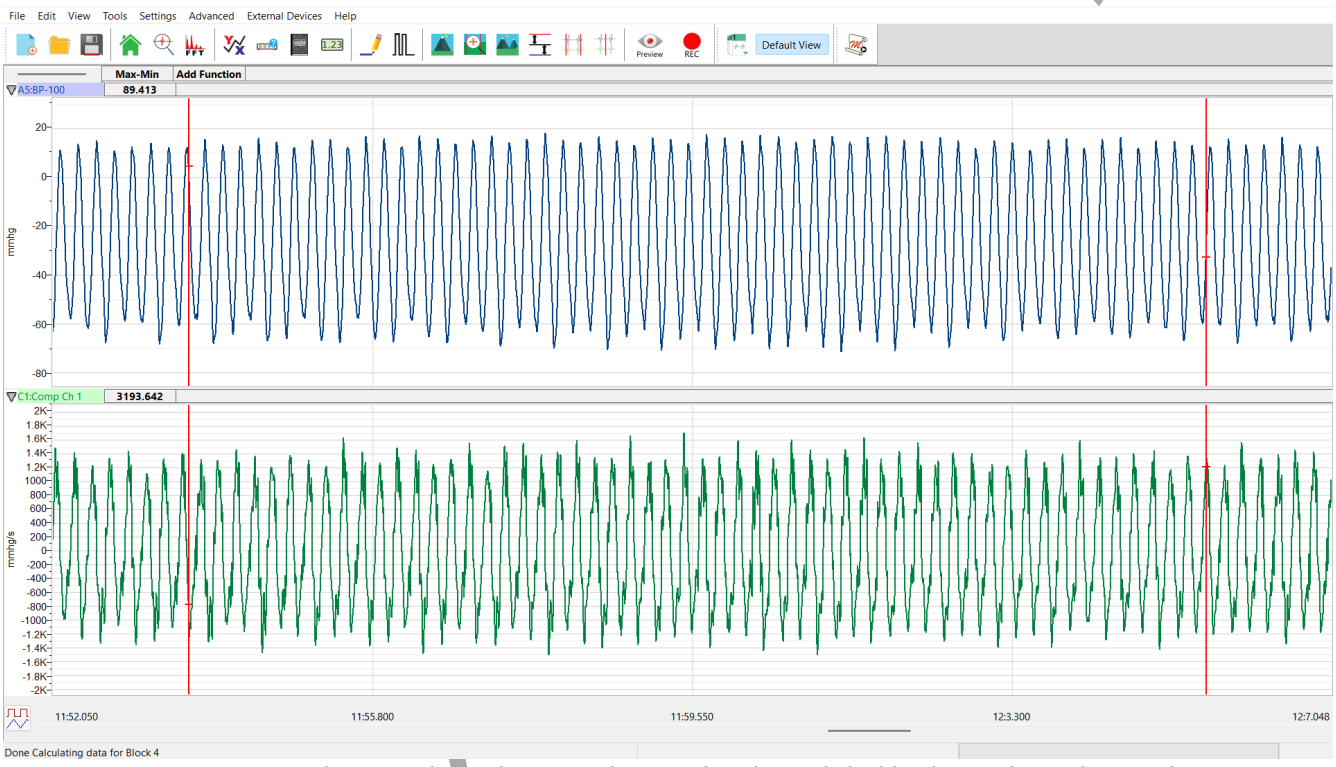

Figure BI-11-S2: Example recording showing the amplitude and dP/dt channels in the Analysis window.

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Data Table

Table BI-11-L1:

Amplitude and Derivative Measurements for Different Tubing				
Material	Diameter (in)	Length (in)	Amplitude (Max-Min)	Derivative (Max-Min)

Questions

Exercise 1

1. Which tubing material produced the largest pressure pulse amplitude?
2. Which tubing material showed the highest max–min dP/dt?
3. How do these measurements relate to compliance?

Exercise 2: Effect of Tubing Diameter

Aim: To observe how tubing compliance affects pulsatile pressure amplitude and max–min dP/dt for varying diameter.

Approximate Time: 30 minutes

Procedure:

Repeat the procedure from Exercise 1, vary tubing diameter.

Questions

Exercise 2

1. How does increasing tubing diameter affect amplitude and dP/dt?

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2. How does tubing diameter relate to the role of large arteries vs. small arteries in the cardiovascular system?

Exercise 3: Effect of Tubing Length

Aim: To observe how tubing compliance affects pulsatile pressure amplitude and max–min dP/dt for varying length.

Approximate Time: 30 minutes

Procedure:

Repeat the procedure from Exercise 1, vary tubing length.

Questions

Exercise 3

1. How did increasing the tubing length affect the pulse amplitude and dp/dt?
2. Why does longer tubing create more damping of pressure waves?

Part 2 – Syringe

Exercise 1: Effect of Tubing Material (Material Stiffness)

Aim: To measure the compliance of two tubing types filled with water (Latex vs. PVC) of identical length and diameter using a syringe and a BP-100 pressure sensor.

Approximate Time: 30 minutes

Procedure:

1. Fill the 25 mL syringe with water. Gently tap to move any air bubbles to the top.
2. Connect the syringe to one side of the test tubing using a luer connector.
3. Connect the opposite end of the test tubing to the BP-100 using a second luer connector. Remove the blue cap on the BP-100 so the output port is open to air.
4. Slowly fill the tubing with water until all air is moved out of the system. Tap the tubing to release small bubbles.
5. Cap the end of the BP-100 to seal the system. Ensure the cap is secured tightly.
6. Disconnect the 25 mL syringe from the test tubing, keeping the open end pointed upward to prevent water loss.
7. Fill the 1 mL syringe (located in the syringe holder) with water.
8. Connect the 1 mL syringe to the test tubing, ensure there are no air bubbles.
9. Switch the recording View to *Part 2 – Syringe.*

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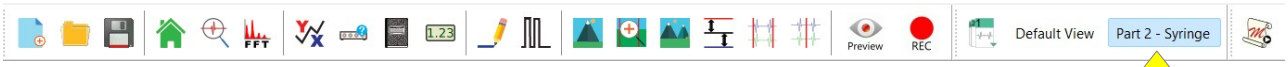

10. Click record to start the recording.
11. Type zero in the Mark box. Click the mark button to mark the recording. This is the starting volume.
12. Gradually increase the volume of water in the tubing by rotating the syringe holder knob in half-turn increments.
13. Type the next volume measurement in the Mark box. Click the mark button to mark the recording.
14. Repeat steps 11 and 12 for a total of six volume-pressure points. The marks should read: 0, 0.5, 1, 1.5, 2, 2.5, and 3.
15. Click Stop to end the recording.
16. Select Save in the File menu.
17. The recording should look like the image below.
18. Repeat the procedure for the second test tubing.

Note: *Be sure to mark each measurement reading correctly for accurate data analysis.*

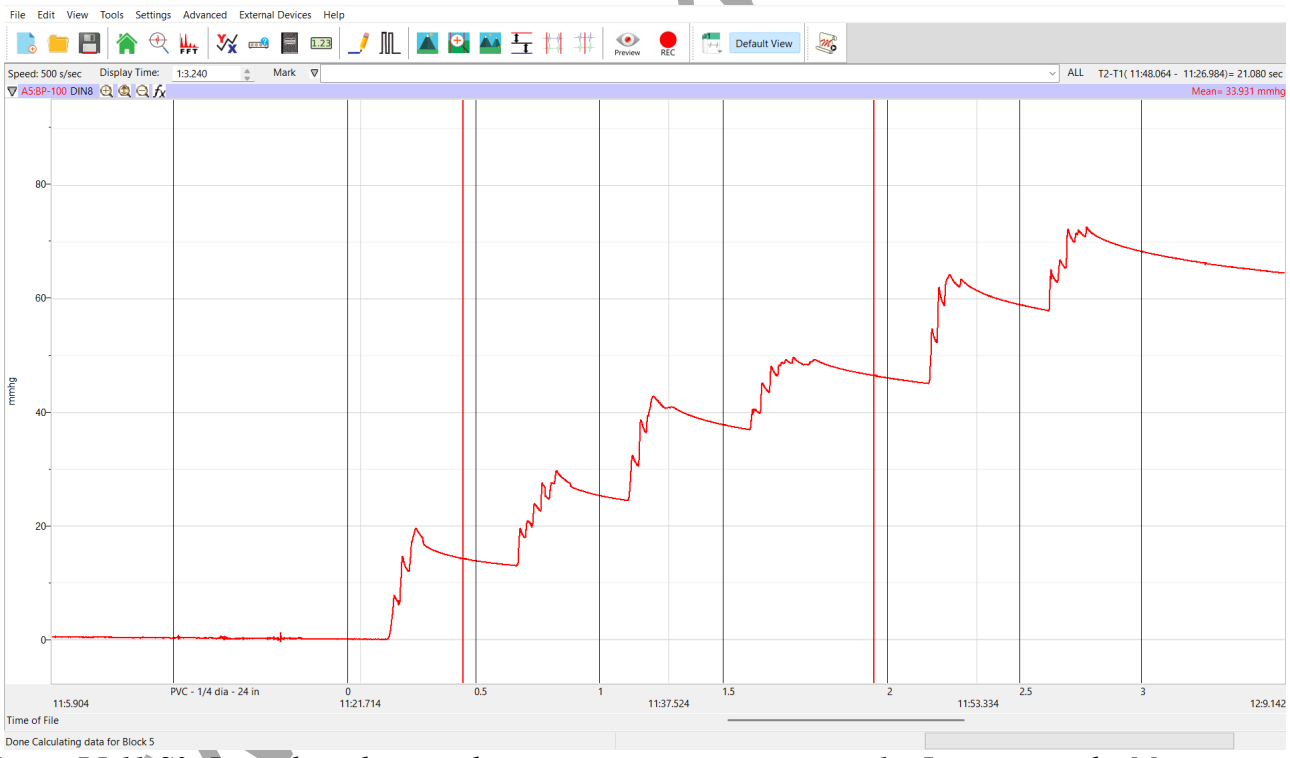

Figure BI-11-S3: Recording showing the increase in pressure using a 1 mL syringe in the Main window. Marks are placed each increment, as the volume of water in the tubing is increased.

Sample Lab

Data Analysis

1. Scroll to the section of data showing all volume marks recorded during the first tubing type in Exercise 1.
2. Use the Display Time icons on the LabScribe toolbar to position this section of recording on the Main window. The required data can also be selected by:
    - Placing the cursors on either side of the section of data needed. Place one cursor just before the initial value mark. Place the second cursor just after the final volume value mark.
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment of data to the width of the Main window.
3. Place the two red cursors around the mark labeled "0". Right click on the channel, and select Units – Set Offset. Set the mean value between the cursors to 0 and click OK. The offset should only be applied to that block.
4. Look at the Function Table that is above the uppermost channel displayed in the Analysis window. The mathematical functions that are listed should include Mean and Mark. The values for these parameters from each channel are seen in the table across the top margin of each channel.
5. Place the cursors on either side of the first mark, as shown below. Once the cursors are placed in the correct positions, the values 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 mean pressure at the first mark.
    - Transfer the name of the mathematical function used to the Journal using the Add Title to Journal function in the pressure channel pull-down menu.
    - Transfer the values to the Journal using the Add Ch. Data to Journal function in the pressure channel pull-down menu.
7. Measure the values for the following parameters from the pressure channel for each mark:
    - Volume, which is Mark on the Pressure channel.
    - Mean Pressure, which is Mean on the Pressure channel.
8. Record the values for each of these parameters in the Journal using one of the procedures described in Step 6.

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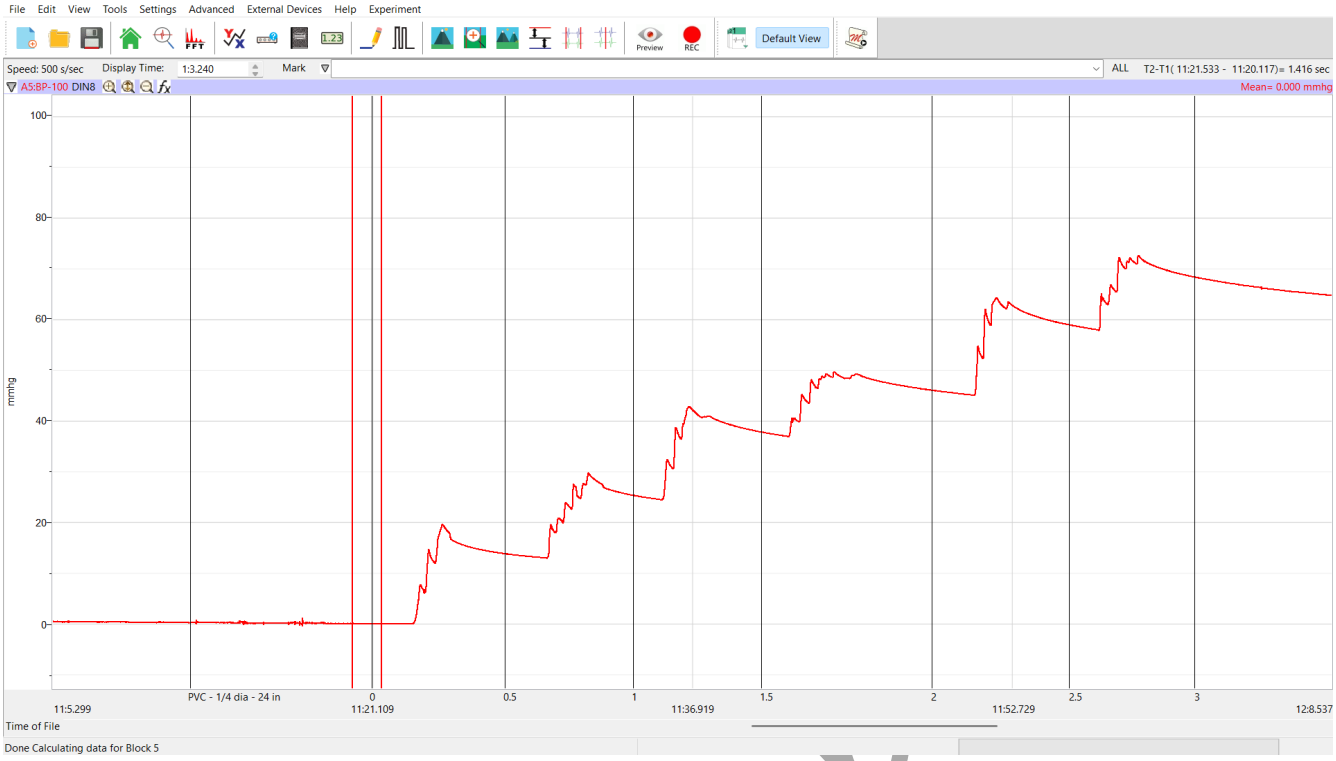

Figure BI-11-S4: Recording showing the increase in pressure using a 50 mL syringe in the Analysis window. Cursors are placed on either side of the initial volume reading.

Questions

Exercise 1

1. Transfer the values for each test tubing type from the Journal into an Excel document. In Excel, plot the pressure values on the x-axis, and the volume values on the y-axis. Add a trend line to the graph.
2. Which tubing material had higher compliance? How can you tell from the graph?
3. Why does stiffer tubing show higher pressure for the same volume?
4. How does tubing material relate to arterial stiffness in the human body?

Exercise 2: Effect of Tubing Diameter

Aim: To measure compliance based on varying diameter (the tubings should be of the same material and length).

Approximate Time: 30 minutes

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Procedure:

Repeat the procedure from Exercise 1, vary tubing diameter.

Questions

Exercise 2

1. Graph the values on the same Excel document. How does increasing tubing diameter affect compliance?
2. How does this relate to vessel radius in the cardiovascular system?

Exercise 3: Effect of Tubing Length

Aim: To calculate compliance based on varying tubing length (the tubings should be of the same material and diameter).

Approximate Time: 30 minutes

Procedure:

Repeat the procedure from Exercise 1, vary tubing length.

Questions

Exercise 3

1. Graph the values on the same Excel document. How does tubing length affect compliance?
2. Why would a longer tube have different pressure-volume behavior than a shorter tube?

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