II. EXPERIMENTAL OBJECTIVES

1.) To observe experimentally, record and/or calculate selected pulmonary volumes and capacities.
2.) To compare the observed values of volume and capacity with average values.
3.) To compare the normal values of pulmonary volumes and capacities of subjects differing in sex, age, weight, and height.

III. MATERIALS

- BIOPAC Airflow Transducer with removable, cleanable head (SS11LA)
  - If using older SS11L transducers with non-removable head, insert into the larger diameter port.
- BIOPAC Bacteriological Filter (AFT1): one per subject; plus, if using calibration syringe, one dedicated to syringe
- BIOPAC Disposable Mouthpiece (AFT2)
- BIOPAC Nose Clip (AFT3)
- BIOPAC Calibration Syringe: 0.6-Liter (AFT6 or AFT6A+AFT11A) *or* 2-Liter (AFT26)
- *optional*—BIOPAC Autoclavable Mouthpiece (AFT8)
- Biopac Student Lab System: software BSL 3.7.5 or above
  data acquisition unit MP36, MP35, MP30 (Windows only), or MP45
- Computer System

IV. EXPERIMENTAL METHODS

For further explanation, use the online support options under the Help Menu.

A. SETUP

FAST TRACK

1. Turn your computer **ON**.
2. Make sure the BIOPAC MP3X unit is **OFF**.
3. Plug the airflow transducer (SS11LA) into Channel 1.
4. Turn **ON** the MP3X Unit.
5. Place a filter onto the end of the calibration syringe.

Setup continues...

DETAILED EXPLANATION

The desktop should appear on the monitor. If it does not appear, ask the laboratory instructor for assistance.

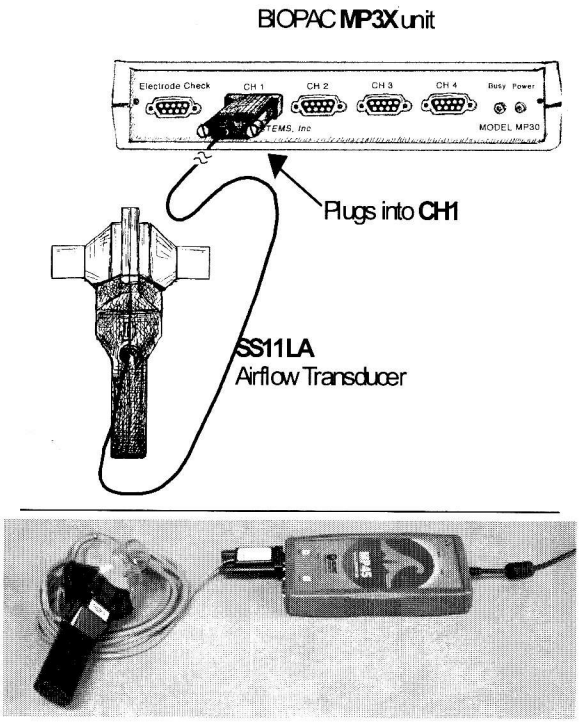


Fig. 12.8 MP3X (top) and MP45 (bottom) equipment connections

- SS11LA needs 5-10 minutes to warm up; during this time, the baseline offset is changing slightly.

6. **Insert** the Calibration Syringe/Filter Assembly into the airflow transducer (Fig. 12.9).

IMPORTANT!
Always insert on the side labeled "Inlet"

The bacteriological filter must be used between the transducer and calibration syringe in order for the data to be accurate. The **filter is required** for calibration and recording because it forces the air to move smoothly through the transducer. This assembly can be left connected for future use. You only need to replace the filter if the paper inside the filter tears.

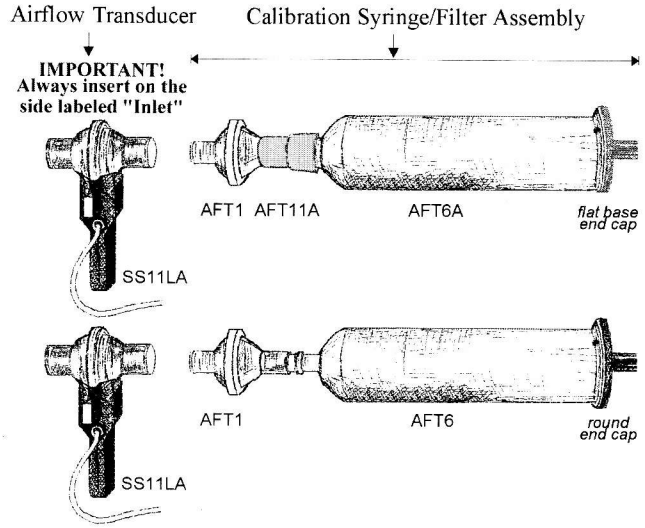


Fig. 12.9

Always insert syringe assembly on the transducer side labeled "**Inlet**" so that the transducer cable exits on the left, as shown in Fig. 12.9.

IMPORTANT: If your lab sterilizes the airflow heads after each use, make sure a clean head is installed now.

7. **Start** the Biopac Student Lab program.
8. Choose Lesson 12 (**L12-Pulmonary Function I**) and click **OK**.
9. Type in your filename and click **OK**.
10. *Optional*: Set Preferences.
    - Choose File > Preferences.
    - Select an option.
    - Select the desired setting and click OK.

Use a unique identifier. Click OK to end default Setup.

This lesson has optional Preferences for data and display while recording. Per your Lab Instructor's guidelines, you may set:

Calibration Syringe Size: 0.61 L (AFT6A/6), 1 L, 2 L (AFT26), 3 L, 4 L, or 5 L
Calibration Syringe Values: set each time or set once and use stored values for the same SS11LA/L with the same MP45
Residual Volume: RV cannot be determined using a normal spirometer or airflow transducer, so the BSL software sets a value between 0 and 5 liters (default is 1 L)
Journal Text: show minimum guiding text vs. detailed text
Grids: show or hide gridlines
Recording Length: allow from 30 seconds to 30 minutes of data

END OF SETUP

B. CALIBRATION

Calibration establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimum performance. Calibration will vary based on the Preference set by your lab instructor.

Pay close attention to the journal instructions for the entire calibration.

Stage 1 – ALWAYS REQUIRED

FAST TRACK

1. Hold the Airflow transducer upright and still (Fig. 12.10).

2. Click **Calibrate**.

3. *IF PROMPTED*—Complete the calibration syringe assembly **BEFORE** clicking **OK**.
   a.) Place a filter onto the end of the calibration syringe.
   b.) Insert the Calibration Syringe/Filter Assembly into the airflow transducer (Fig. 12.12).
   c.) Pull the Calibration Syringe Plunger all the way out.
   d.) **Read** the Stage 2 procedure to prepare for it.
   e.) Hold the syringe horizontally and let the transducer hang upright off the end with no support.

IMPORTANT!
Always insert on the side labeled "Inlet."

Calibration continues…

DETAILED EXPLANATION

Calibration Stage 1 zeroes the baseline, which is critical for Airflow to Volume calculation. For this stage, there must be no airflow through the transducer and the transducer must be upright and still as the baseline can shift slightly with orientation changes due to gravity effects.

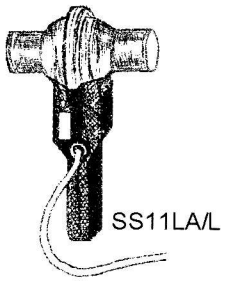


Fig. 12.10

The first calibration stage will run for 4 seconds.

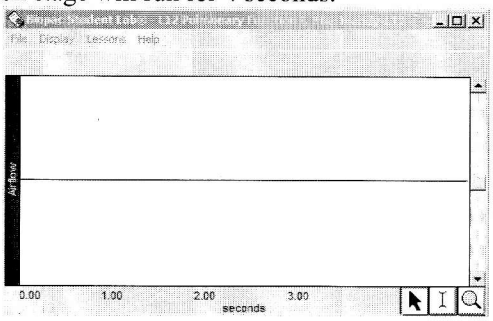
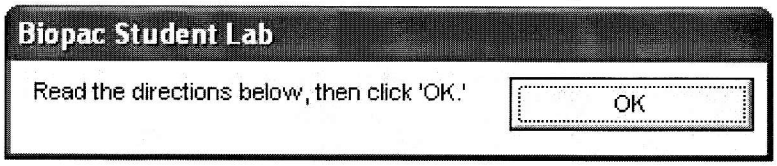


Figure 12.11 Calibration stage 1 – always required

If prompted, read the Stage 2 procedure BEFORE clicking OK.



- **Do not click OK until you are completely ready to proceed.**

Based on lesson Preference settings, the calibration syringe may not be required. If prompted, complete the assembly BEFORE clicking OK.
The bacteriological filter must be used between the transducer and calibration syringe in order for the data to be accurate. The filter is required for calibration and recording because it forces the air to move smoothly through the transducer. This assembly can be left connected for future use. You only need to replace the filter if the paper inside the filter tears.

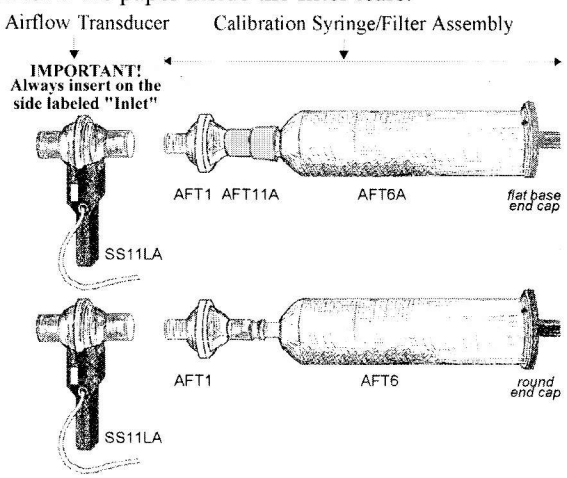


Fig. 12.12

IMPORTANT

If your lab sterilizes the airflow heads after each use, make sure a clean head is installed now.

IMPORTANT

Never hold onto the airflow transducer handle when using the calibration syringe or the syringe tip may break.

Stage 2 – If "Use stored values" Preference set, complete if prompted.

4. Click **OK**.

When you click **OK**, the second stage of calibration will begin, and will run until you click **End Calibration** after cycling the syringe.

Calibration Stage 2 corrects the transducer amplitude and compensates for Standard Temperature and Pressure (STP). After a known volume of air is passed through the transducer (such as 5 syringe cycles, which provides for some airflow variations), the software will determine a set of "correction factors" to be applied on the airflow data during the Subject recordings.

5. Starting with the syringe plunger all the way out, cycle the plunger in and out completely 5 times (10 strokes).

Hold the syringe assembly as shown in Fig. 12.12 above.

Use a rhythm of about 1 second per stroke with 2 seconds rest between strokes, i.e., push the plunger in for approximately 1 second, wait 2 seconds, pull the plunger out, wait 2 seconds, and repeat 4 more times. Click **End Calibration** when done.

6. Click End Calibration.

At the end of calibration, your screen should resemble Fig. 12.13.

7. Check calibration data.

- If similar, validate the data (optional Step 8) or proceed to the Data Recording section.

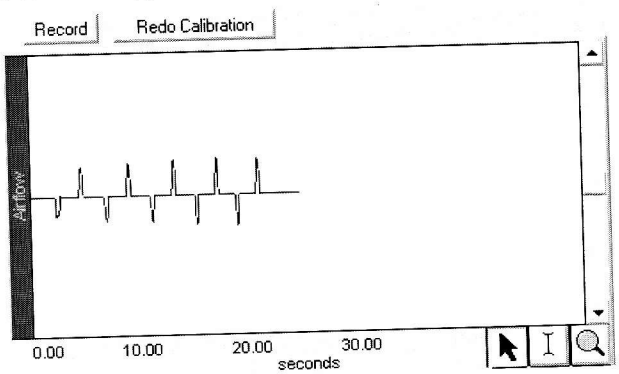


Figure 12.13

The first push of the syringe plunger should have resulted in a downward deflection of the data. If your data shows 5 downward deflections and 5 upward deflections, you may proceed to the Data Recording section.

- If different, **Redo Calibration**.

If the first stroke resulted in an upward deflection, you will need to change the calibration assembly (insert the assembly into the other port of the airflow transducer) and repeat calibration. If the data shows any large spikes, you must repeat calibration. Click **Redo Calibration** to repeat the calibration sequence.

OPTIONAL

8. *Optional* Validate Calibration.

a) Click Record.

b) Cycle the AFT6 syringe plunger in and out completely 3 times (6 strokes).

c) Click Stop.

d) Measure P-P on CH2 Volume (Fig. 12.14) to confirm the result matches the syringe volume:

AFT6=0.6 L
AFT26 = 2 L

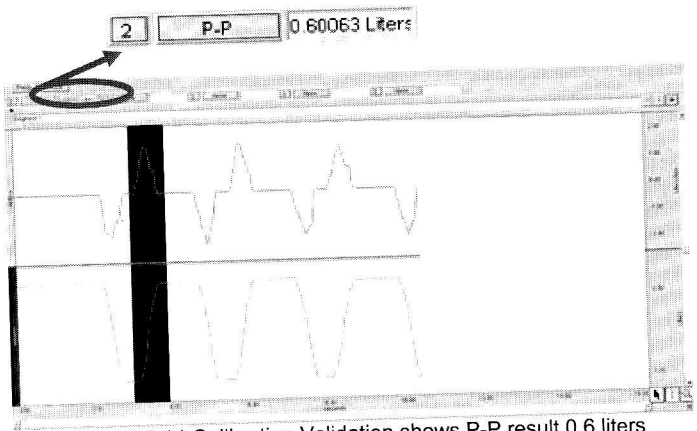


Figure 12.14 Calibration Validation shows P-P result 0.6 liters

e) Click Redo to proceed with Subject recording (or click Done and repeat calibration if necessary).

END OF CALIBRATION

C. Recording Lesson Data

FAST TRACK Recording

1. Prepare for the recording.

IMPORTANT!
Subject must be relaxed to obtain accurate measures.

2. Prepare the transducer-filter (if applicable)-mouthpiece assembly:

To be safe, follow this procedure precisely to make sure the airflow transducer is sterile.

- **If** using the **SS11LA** transducer and **not sterilizing** the head after each use: Insert a filter and mouthpiece into the airflow transducer on the side labeled "Inlet."

IMPORTANT!
Always insert on the side labeled "Inlet"

- **If** using the **SS11LA** transducer and **sterilizing** the head after each use: Insert a disposable mouthpiece (BIOPAC AFT2) or an autoclavable mouthpiece (BIOPAC AFT8) into the airflow transducer on the side labeled "Inlet."

Recording continues…

Detailed Explanation of Recording Steps

In order to work efficiently, read this entire section so you will know what to do for each recording segment.

Following the procedure precisely is very important, as the calculation from airflow to volume is very sensitive.

Subject should be seated, facing away from the computer monitor, relaxed, with eyes closed while you review the lesson.

Hints for obtaining optimal data:

a) **Subject** should be seated, facing away from the computer monitor, relaxed, with eyes closed.

b) **Subject** should insert mouthpiece and begin breathing normally BEFORE the recording is started since the mouthpiece may influence normal values.

c) Always insert on and breathe through the transducer side labeled "Inlet."

d) Keep the Airflow Transducer upright at all times (Fig. 12.17).

e) A breath is considered a complete inhale-exhale cycle. If you start the recording on an inhale, try to end on an exhale, and vice-versa. This is not absolutely critical, but does increase the accuracy of the Airflow to Volume calculation.

IMPORTANT: If your lab sterilizes the airflow heads after each use, make sure a clean head is installed now.

Have **Subject** personally remove the filter and mouthpiece from the plastic packaging. This mouthpiece will become **Subject's** personal mouthpiece. It is advisable to write **Subject's** name on the mouthpiece and filter with a permanent marker so they can be reused later.

If using **SS11LA** transducer and not sterilizing the head after each use: insert a filter and mouthpiece into the airflow transducer on the side labeled "Inlet."

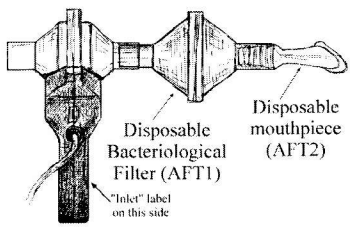


Fig. 12.15 SS11LA with unsterilized head

If using **SS11LA** transducer and sterilizing the head after each use: insert a mouthpiece into the airflow transducer on the side labeled "Inlet."

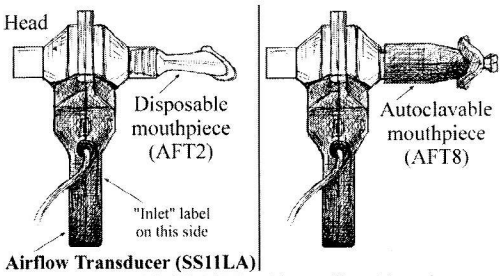


Fig. 12.16 SS11LA with sterilized head

3. Prepare the **Subject**:

   a.) **Subject** should place his/her personal nose clip on nose.

   b.) **Subject** should breathe normally for 20 seconds through the Airflow Transducer BEFORE Record is clicked.

IMPORTANT!
Subject must remain relaxed and always breathe through the side labeled "Inlet"

4. Click **Record**.

   a) Breathe normally for 5 breaths.

   b) Inhale as deeply as you can.

   c) Exhale as deeply as you can.

   d) Breathe normally for 5 breaths.

5. Click **Stop**.

6. Review the data on the screen.

   - If similar, go to Step 9.

   - If different, click **Redo**.

7. Click **Done**.

8. Click **Yes**.

END OF RECORDING

A breath is considered a complete inhale-exhale cycle.

Subject should be relaxed with eyes closed for "normal breathing."

Allow time for Subject to acclimate to the mouthpiece **BEFORE** clicking Record.

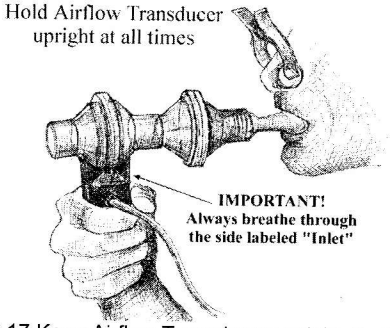


Fig. 12.17 Keep Airflow Transducer upright at all times

For accurate measures, Subject must be completely relaxed, with eyes closed, and breathing normally. The mouthpiece will influence Subject's breathing, so allow time for Subject to acclimate to the mouthpiece **BEFORE** clicking Record.

- **A breath is considered a complete inhale-exhale cycle.** Subject should be relaxed with eyes closed and not facing the computer.
- If you start the recording on an inhale, try to end on an exhale, and vice-versa.

As soon as **Stop** is clicked, the Biopac Student Lab software will automatically calculate volume data based on the recorded airflow data. At the end of the calculation, both waveforms will be displayed on the screen (Fig. 12.18).

Data should resemble Fig.12.18, showing a positive spike for inhalation and a negative spike for exhalation.

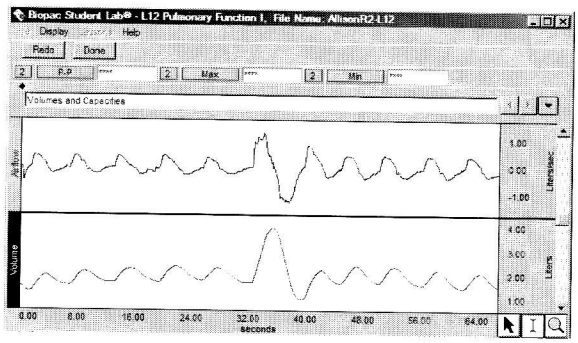


Fig. 12.18

Data might be different if the procedure wasn't followed precisely, i.e. Subject coughed or air escaped, or if the wrong Residual Volume was used (see Journal for value used and change via File > Preferences if necessary).

If different, click **Redo** and redo the recording by repeating Steps 5-8. Note that once you press **Redo**, the data you have just recorded will be erased.

After **Done** is pressed, data will automatically be saved in the specified "Data Files" folder and a dialog with options will be generated. Make your choice and continue as directed.

If choosing the "Record from another Subject" option:

a) You will not need to recalibrate the airflow transducer with the syringe (Calibration Stage 2).

b) Remember to have each person use his/her own mouthpiece, bacterial filter and nose clip.

c) Repeat Recording Steps 2-8 for each new **Subject**.

d) Each person will need to use a unique file name.

V. DATA ANALYSIS

FAST TRACK Data Analysis

1. Enter the **Review Saved Data** mode and choose the correct file.
   - Note channel number (CH) designations:

Channel	*Displays*
CH 1	**Airflow** (hidden)
CH 2	**Volume**

   Optional: To review Airflow data, "Ctrl+Click" (Windows) or "Option+click" (Mac) the channel number box.
   - Note the measurement box settings:

Channel	*Measurement*
CH 2	**P-P**
CH 2	**Max**
CH 2	**Min**
CH 2	**Delta**

2. Review the measurements described in the Introduction to identify the appropriate selected area for each:
   - Total Lung Capacity
   - Tidal Volume
   - Inspiratory Reserve Volume
   - Expiratory Reserve Volume
   - Vital Capacity
   - Expiratory Capacity
   - Inspiratory Capacity
   - Functional residual Capacity
   - Residual Volume

Data Analysis continues…

DETAILED EXPLANATION OF DATA ANALYSIS STEPS

Enter the Review Saved Data mode.

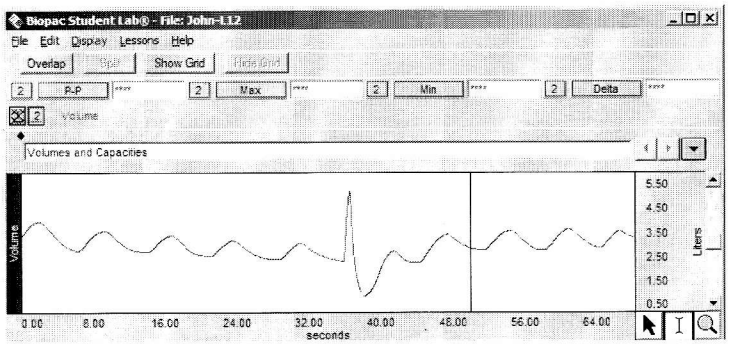


Fig. 12.19

The Airflow data does not have a lot of meaning for this lesson and may confusing at first glance, but it contains an interesting perspective on the recording. Note that the vertical scale of the airflow waveform is in Liters per second (Liters/sec.), and that the data is centered on zero. Looking at the CH 1 graph, you can see that with each exhale, a downward pointing curve appears. The deeper an inhale, the larger the positive peak; the more forceful an exhale, the larger the negative peak.

The measurement boxes are above the marker region in the data window. Each measurement has three sections: channel number, measurement type, and result. The first two sections are pull-down menus that are activated when you click them. The following is a brief description of these specific measurements.

P-P: finds the maximum value in the selected area and subtracts the minimum value found in the selected area.

Max: displays the maximum value in the selected area.

Min: displays the minimum value in the selected area.

Delta: computes the difference in amplitude between the last point and the first point of the selected area.

The "selected area" is the area selected by the I-Beam tool (including endpoints).

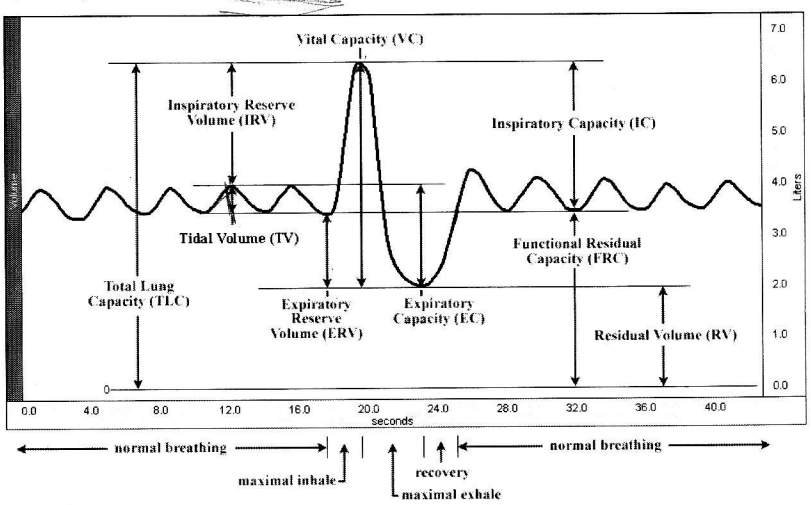


Fig. 12.20 Measurement areas for respiratory volumes and capacities

3. Measure observed VC (P-P).

   A

4. Take two measures for an averaged TV calculation:

   a) Use the **I-beam** cursor to select the **inhalation** of cycle 3 and note the P-P result (Fig. 12.22). The selected area should be from the valley to the peak of the third cycle.

      B

   b) Use the **I-beam** cursor to select the **exhalation** of cycle 3 and note the P-P result (Fig. 12.23). The selected area should be from the peak to the valley of the third cycle.

      B

5. Use the I-beam cursor and measurement tools to observe the following volumes and capacities (defined in Fig. 12.24):

   a) IRV (Delta)
   b) ERV (Delta)
   c) RV (Min)
   d) IC (Delta)
   e) EC (Delta)
   f) TLC (Max)

   B

6. Save or Print the data file.

7. Quit the program.

END OF DATA ANALYSIS

The **P-P** measurement can be used to obtain VC (Fig. 12.21).

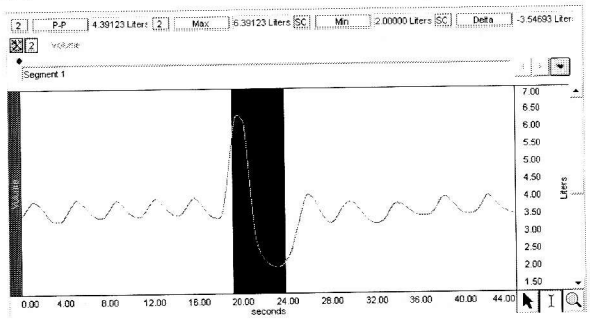


Figure 12.21 Example of VC from P-P measure

The **P-P** measurement in Fig. 12.22 represents the first value required for the averaged TV calculation.

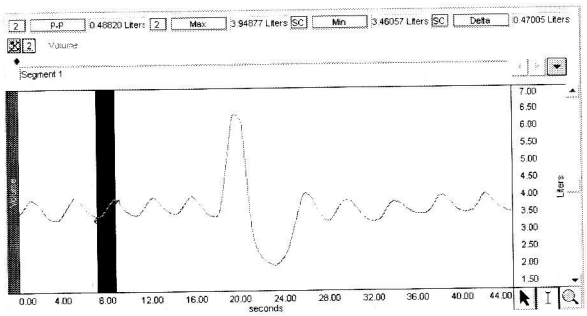


Fig. 12.22 Inhalation of third breath cycle selected to measure P-P

The **P-P** measurement in Fig. 12.23 represents the second value required for the averaged TV calculation.

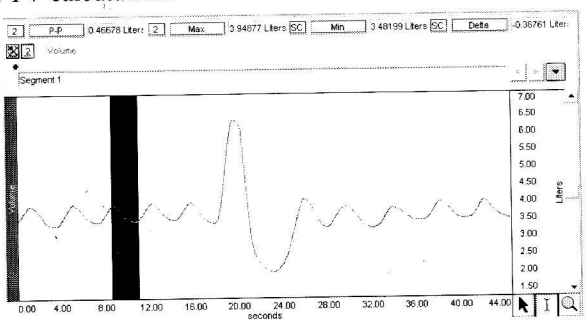


Fig. 12.23 Exhalation of third breath cycle selected to measure P-P

The **Delta** measurement can be used to obtain IRV, ERV, and other measurements (Fig. 12.24).

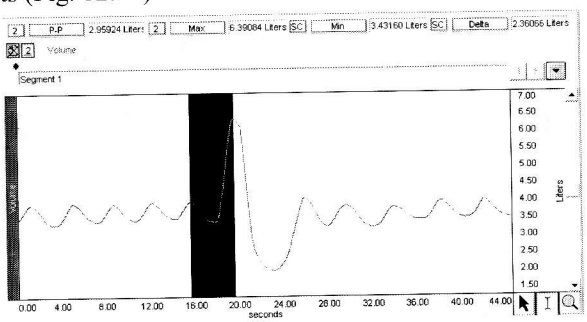


Fig. 12.24 Example of measurements for TLC (Max), RV (Min), and IRV (Delta)

You may save the data to another location, save notes that are in the journal, or print the data file.

END OF LESSON 12

Complete the Lesson 12 Data Report that follows.