Physiology Lessons
for use with the
Biopac Student Lab

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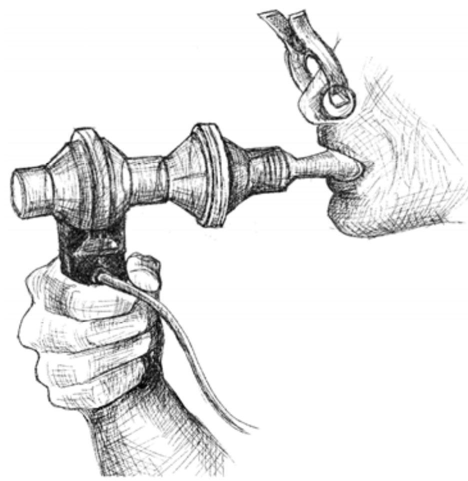
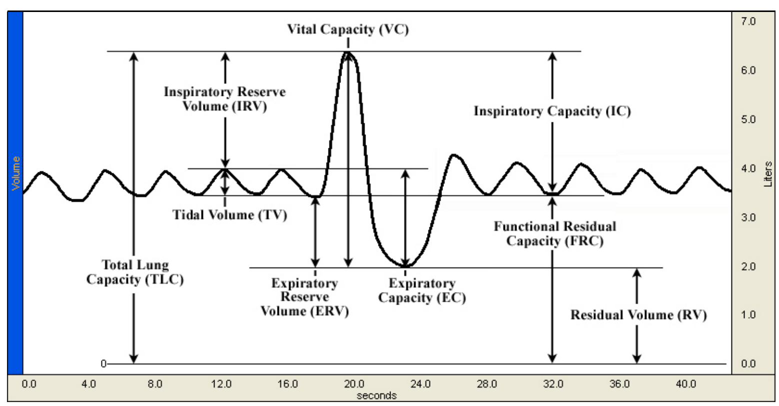
Lesson 12

PULMONARY FUNCTION I

Volumes and Capacities





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 (SS11LA)
- BIOPAC Bacteriological Filter (AFT1)
- BIOPAC Disposable Mouthpiece (AFT2)
- BIOPAC Nose Clip (AFT3)
- BIOPAC 0.6-Liter (AFT6) *or* 2-Liter Calibration Syringe (AFT26)
- BIOPAC Autoclavable Mouthpiece (AFT8) — *optional*
- Computer system
- Biopac Student Lab 3.7
- BIOPAC data acquisition unit (MP36, MP35, or MP30 with cable and power)

IV. EXPERIMENTAL METHODS

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

A. Set Up

FAST TRACK SET UP

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

Set Up continues…

Detailed Explanation of Set Up

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

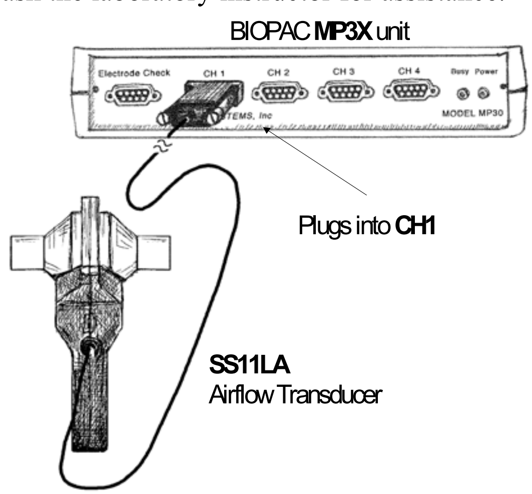


Fig. 12.3

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.

6. **Insert** the Calibration Syringe/Filter Assembly into the airflow transducer (Fig. 12.4).

IMPORTANT!
Always insert on the side labeled "Inlet"

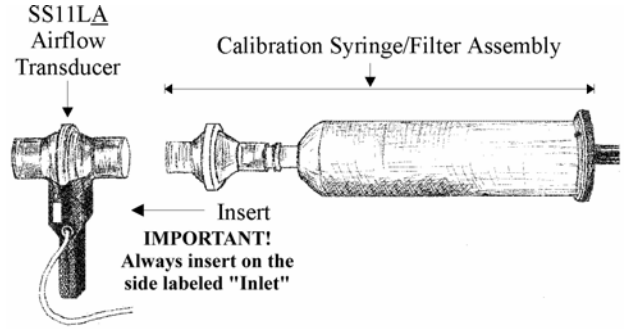


Fig. 12.4

If using SS11LA transducer with removable, cleanable head, always insert syringe assembly on the transducer side labeled "**Inlet**" so that the transducer cable exits on the left, as shown in Fig. 12.4.

- **If using SS11L** transducer with non-removable head, insert syringe assembly into the larger diameter port.

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-LUNG-1**).
9. Type in your filename.
10. Click **OK**.

Use a unique identifier.

This ends the Set Up procedure.

END OF SET UP

B. CALIBRATION

The calibration procedure establishes the hardware's internal parameters (such as gain, offset, and scaling) and is critical for optimum performance. **Pay close attention to the entire calibration procedure.**

FAST TRACK Calibration

1. Pull the Calibration Syringe Plunger all the way out and hold the Calibration Syringe/Filter Assembly upright (Fig. 12.5).

NOTE: If you have previously calibrated the SS11LA Airflow Transducer for Lesson 12 or 13, and have not exited the BSL software or changed the transducer, BSL has saved the prior calibration data.
- Go to **Step 1** of the **Recording Data** section of this lesson if you wish to begin recording data.
- Click **Redo Calibration** if you wish to recalibrate the transducer.

Calibration continues…

DETAILED EXPLANATION OF CALIBRATION STEPS

The Airflow Transducer is sensitive to gravity so it needs to be held upright throughout the calibration and recording.

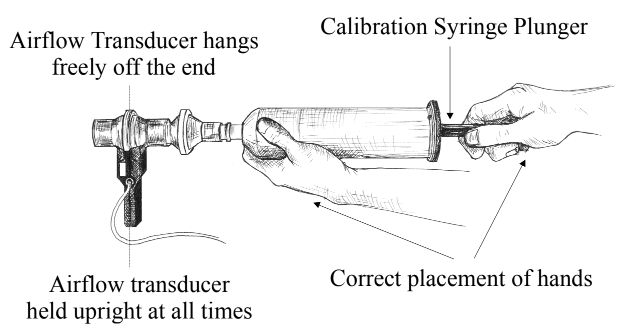
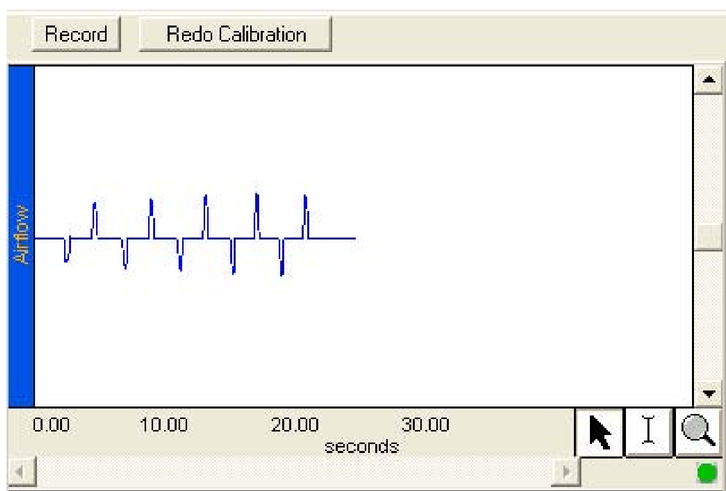


Fig. 12.5

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

2. Click **Calibrate**.	The first calibration procedure stage will run for 8 seconds and end with an alert box. **IMPORTANT**: Leave the plunger extended and hold the assembly steady and upright during the entire calibration procedure. Do not touch the plunger because any pressure at this stage will cause inaccurate results.
3. Prepare for the second calibration stage.	Stage 1 of the calibration procedure ends with an alert box asking if you have read the directions in the journal. Read the directions in Step 5 and/or the journal so that, once the second calibration procedure starts, you understand the procedures.
4. Click **Yes** after reading the alert box.	Do not click on the **Yes** button until you are completely ready to proceed. When you click **Yes**, the second stage of the calibration procedure will begin, and will run until you click **End Calibration**.
5. Cycle the syringe plunger in and out completely 5 times (10 strokes). 6. Click **End Calibration**.	Hold the syringe assembly as shown in Fig. 12.5 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. **Note**: The calibration procedure is required because of the complexity of the Airflow to Volume calculation. The accuracy of this conversion is aided by analyzing the airflow variations occurring over five complete cycles of the calibration syringe. Additional cycles would also help, but only with diminishing return rates. Five cycles turns out to be an adequate number of cycles for accurate calibration.
7. **Check** your calibration data.	At the end of the calibration recording, your screen should resemble Fig. 12.6.  Figure 12.6
➢ If <u>correct</u>, go to the Data Recording section**.**	If your data shows 5 downward deflections and 5 upward deflections, you may proceed to the Data Recording section.
➢ If <u>incorrect</u>, **Redo Calibration**.	If the data shows any large spikes, then you must redo calibration by clicking **Redo Calibration** and repeating the entire calibration sequence.

END OF CALIBRATION

C. RECORDING LESSON DATA

FAST TRACK Recording

1. ***OPTIONAL***: Validate Calibration:
   a) Click Record.
   b) Cycle the AFT6 syringe plunger in and out completely 5 times (10 strokes).
   c) Click Stop.
   d) Measure P-P on CH2 Volume to confirm the result is 0.6 liters (Fig. 12.7)
   e) Click Redo and proceed with Subject recording (or click Done and repeat calibration if necessary).
2. Prepare for the recording.

IMPORTANT!
Subject must be relaxed to obtain accurate measures.

Recording continues…

DETAILED EXPLANATION OF RECORDING STEPS

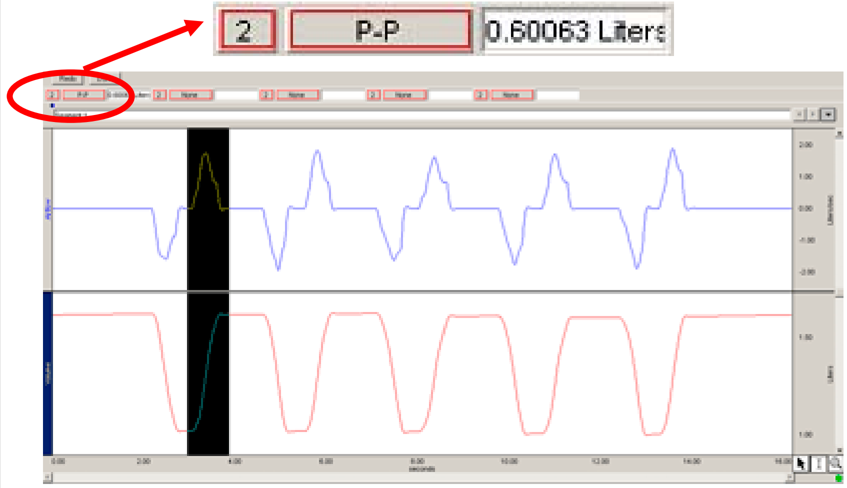


Figure 12.7 Calibration Validation shows P-P result 0.6 liters

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.

Check the last line of the journal and note the total amount of time available for the recording. Stop each recording segment as soon as possible so you don't use an excessive amount of time (time is memory).

Note: Residual Volume (RV) cannot be determined using a normal spirometer or airflow transducer, so the Biopac Student Lab software uses a default of 1 Liter. If 1 Liter of RV is not desired, see your Instructor to change the Preference.

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. 12.11).
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.

3. Insert a clean mouthpiece (and filter if applicable) into the airflow transducer as described below:

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

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

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

- **If** using the **SS11LA** transducer and **sterilizing** the head after each use:

IMPORTANT!
Always insert on the side labeled "Inlet"

If using **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."

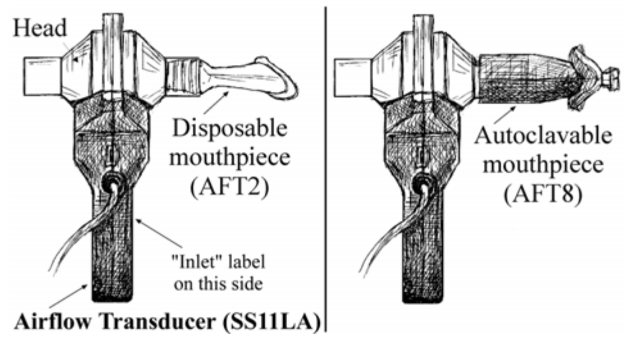


Fig. 12.8 SS11LA with sterilized head

- **If** using the **SS11LA** transducer and **not sterilizing** the head after each use:

IMPORTANT!
Always insert on the side labeled "Inlet"

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."

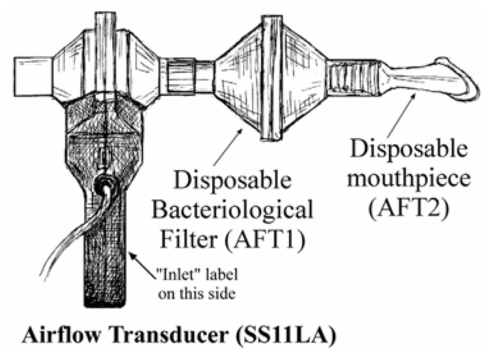


Fig. 12.9 SS11LA with unsterilized head

- **If** using the **SS11L**:

If using **SS11L** transducer with non-removable head, insert a new filter and mouthpiece into the <u>larger diameter port</u>.

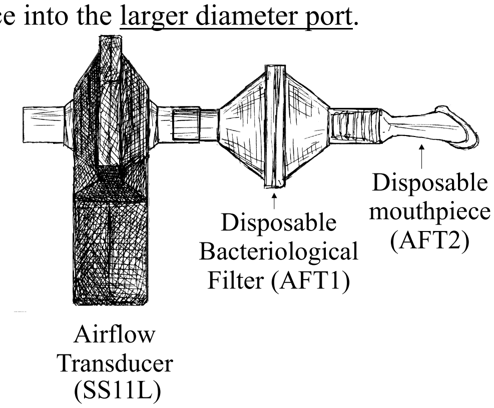


Fig. 12.10 SS11L

4. Subject should place his/her personal nose clip on nose.

Recording continues…

5. Breathe normally for 20 seconds through the Airflow Transducer **BEFORE** clicking Record.

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

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.

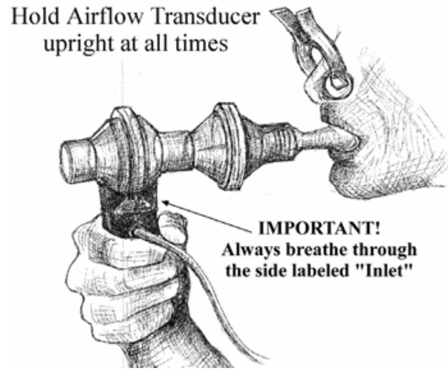


Fig. 12.11 Keep the Airflow Transducer upright at all times

6. 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.

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

7. Click **Stop**.

As soon as the **Stop** button is pressed, 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. 12.12).

8. Review the data on the screen.
   - If correct, go to Step 9.

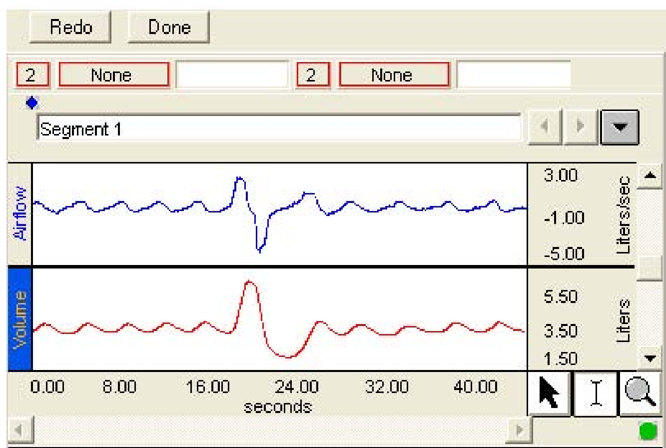


Fig. Fig. 12.12

Your data should resemble Fig.12.12, showing a positive spike for inhalation and a negative spike for exhalation.

   - If incorrect, click **Redo**.

The data would be incorrect if you feel you didn't follow the procedure precisely, i.e. you coughed or air escaped.

In this case, you should redo the recording by clicking **Redo** and repeating Steps 5-8. Note that once you press **Redo**, the data you have just recorded will be erased.

Recording continues…

9. Click **Done**.

After you press **Done,** your data will automatically be saved in the specified "Data Files" folder. A pop-up window with options will appear. 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. For this reason, we recommend that all recordings be completed before you proceed to Data Analysis.

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

c) Repeat Recording Steps 1-7 for each new **Subject**.

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

END OF RECORDING

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**
CH 2	**Volume**

2. Turn **OFF** Channel 1, Airflow.

   Optional: Review Airflow data before turning Channel 1 off.

Data Analysis continues…

DETAILED EXPLANATION OF DATA ANALYSIS STEPS

Enter the Review Saved Data mode.

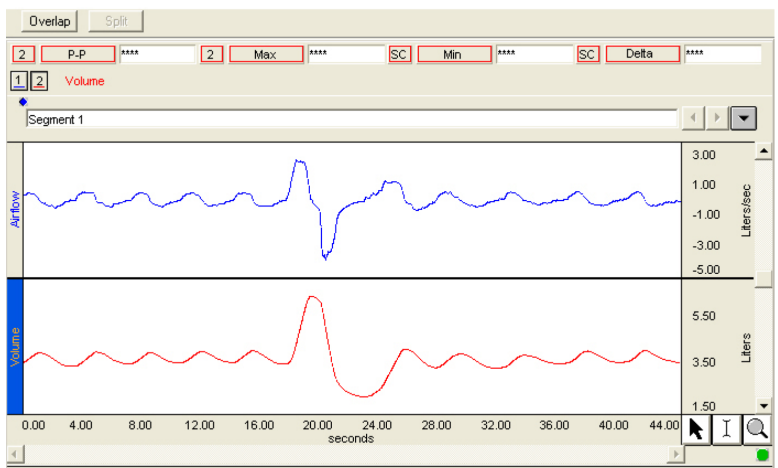


Fig. 12.13

Note: Airflow (Channel 1) and Volume (Channel 2) data are shown simultaneously. First, concentrate on the Volume data.

To toggle a channel ON/OFF, click on the channel number box and hold down the "Ctrl" key.

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 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.

3. Set up the measurement boxes as follows:

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

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 on 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 the endpoints)

4. 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

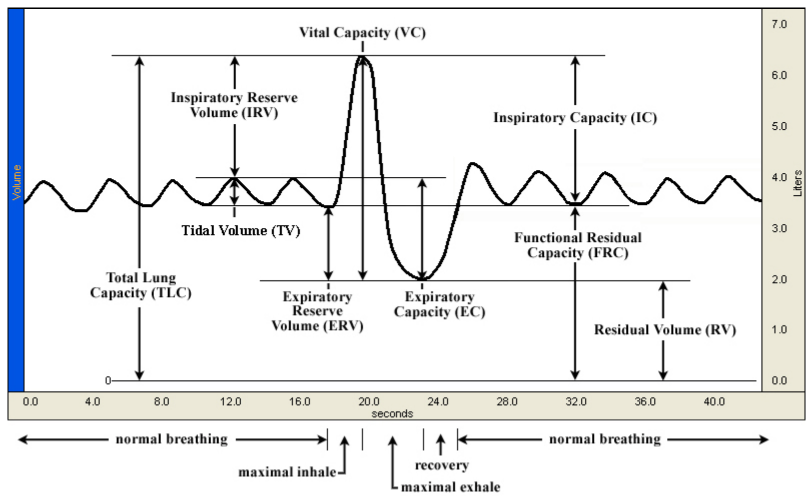


Fig. 12.14 Measurement areas for respiratory volumes and capacities

5. Measure observed VC (P-P).

A

The **P-P** measurement can be used to obtain VC (Fig. 12.15).

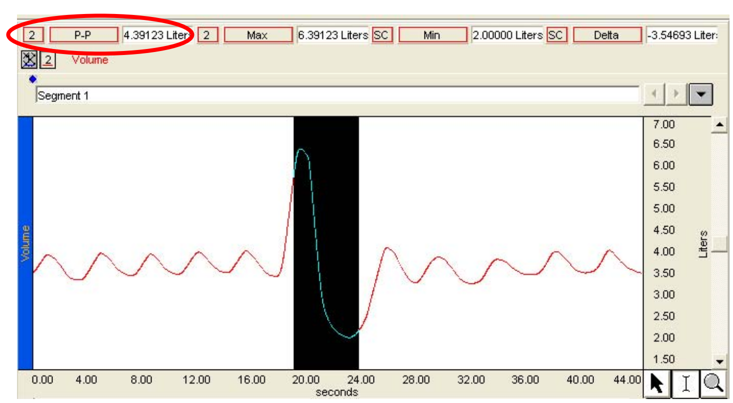


Figure 12.15 Example of VC from P-P measure

Data Analysis continues…

6. 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. 12.16). The selected area should be from the valley to the peak of the third cycle.

   B

The **P-P** measurement in Fig. 12.16 represents the first value required for the averaged TV calculation.

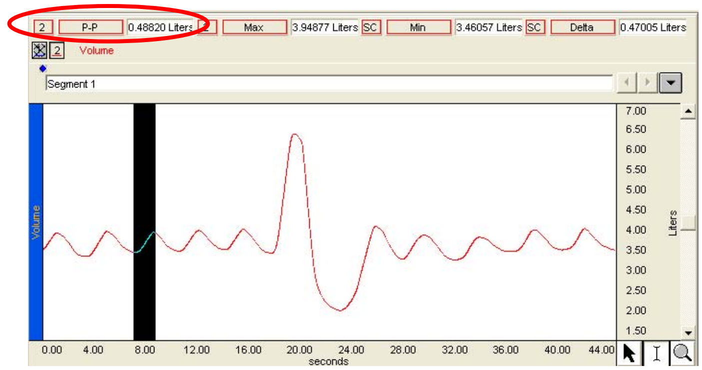


Fig. 12.16 Inhalation of third breath cycle selected to measure P-P

   b) Use the **I-beam** cursor to select the **exhalation** of cycle 3 and note the P-P result (Fig. 12.17). The selected area should be from the peak to the valley of the third cycle.

   B

The **P-P** measurement in Fig. 12.17 represents the second value required for the averaged TV calculation.

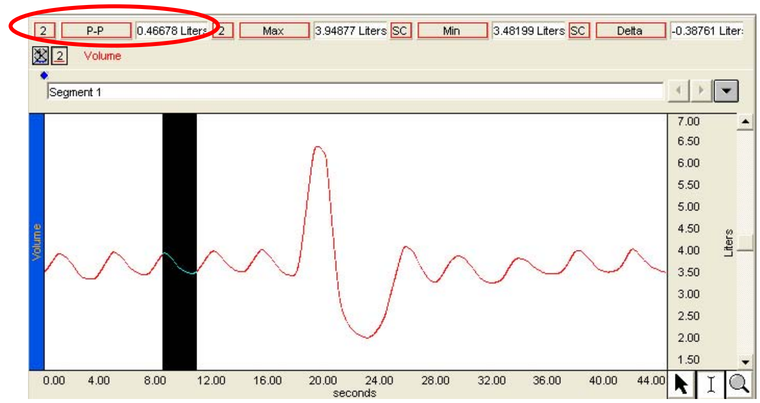


Fig. 12.17 Exhalation of third breath cycle selected to measure P-P

7. Use the I-beam cursor and measurement tools to observe the following volumes and capacities (defined in Fig. 12.14):

   a) IRV (Delta)

   b) ERV (Delta)

   c) RV (Min)

   d) IC (Delta)

   e) EC (Delta)

   f) TLC (Max)

   B

The **Delta** measurement can be used to obtain IRV, ERV, and other measurements (Fig. 12.18).

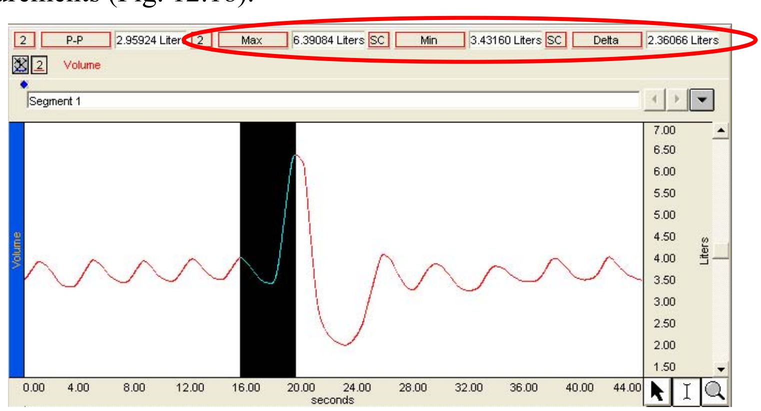


Fig. 12.18 Example of measurements for TLC (Max result), RV (Min result), and IRV (Delta result)T

8. Save or Print the data file.

9. Exit the program.

END OF DATA ANALYSIS

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

END OF LESSON 12

Complete the Lesson 12 Data Report that follows.

PULMONARY FUNCTION I
Volumes and Capacities

DATA REPORT

Student's Name: ____________________

Lab Section: ____________________

Date: ____________________

Subject Profile

Name____________________ Height__________

Age____________________ Weight__________

Gender: Male / Female

I. Measurements

A. Vital Capacity

i) **Predicted**: Use the equation below to calculate your **Predicted Vital Capacity**:_________ liters
A1

Equations for Predicted Vital Capacity	
Male	V.C. = 0.052H - 0.022A – 3.60
Female	V.C. = 0.041H - 0.018A – 2.69

Where

V.C. Vital Capacity in liters
H Height in centimeters
A Age in years

ii) **Observed**: Use the P-P measurement result to note **Observed Vital Capacity**:__________ liters
A2

iii) Observed *vs.* Predicted

What is the Subject's observed Vital Capacity to predicted Vital Capacity as a percentage?

Observed VC /Predicted VC = A1/A2 = _________ liters x 100= __________%

Note: Vital capacities are dependent on other factors besides age and height. Therefore, 80% of predicted values are still considered "normal."

B. Volume & Capacity Measurements

Complete Table 12.2 with the requested measurement results and calculate results per the formulas provided.

Table 12.2 Measurements

Title		Measurement Result	Calculation
Tidal Volume	TV	a = P-P Cycle 3 inhalation: b = P-P Cycle 3 exhalation:	(a + b) / 2 =
Inspiratory Reserve Volume	IRV	Delta	
Expiratory Reserve Volume	ERV	Delta	
Residual Volume	RV	Min	Default = 1 (*Preference setting*)
Inspiratory Capacity	IC	Delta	TV + IRV =
Expiratory Capacity	EC	Delta	TV + ERV =
Functional Residual Capacity	FRC		ERV + RV =
Total Lung Capacity	TLC	Max	IRV + TV + ERV + RV =

C. Observed vs. Predicted Volumes

Using data obtained for Table 12.2, compare the Subject's lung volumes with the average volumes presented in the Introduction.

Table 12.3 Average Volumes *vs.* Measured Volumes

Volume Title		Average Volume	Measured Volume
Tidal Volume	TV	Resting subject, normal breathing: TV is approximately 500 ml. During exercise: TV can be more than 3 liters	greater than equal to less than
Inspiratory Reserve Volume	IRV	Resting IRV for young adults is males = approximately 3,300 ml females = approximately 1,900 ml	greater than equal to less than
Expiratory Reserve Volume	ERV	Resting ERV for young adults is males = approximately 1,000 ml females = approximately 700 ml	greater than equal to less than

II. Questions

D. Why does predicted vital capacity vary with height?

E. Explain how factors other than height might affect lung capacity.

F. How would the volume measurements change if data were collected after vigorous exercise?

G. What is the difference between volume measurements and capacities?

H. Define **Tidal Volume**.

I. Define **Inspiratory Reserve Volume**.

J. Define **Expiratory Reserve Volume**.

K. Define **Respiratory Volume**.

L. Define **Pulmonary Capacity**.

M. Name the **Pulmonary Capacities**.

End of Lesson 12 Data Report