

Exercise 37A - Activity 5c: Visualizing Respiratory Variations

Measuring Respiratory Volumes using iWorx

In this activity, you will measure respiratory volumes using the iWorx® spirometer. An example of these volumes is demonstrated in the spirogram in Figure 37A.7. Since it is not possible to measure residual volume (RV) using the spirometer, assume that it is 1.0 liter for each subject, which is a reasonable estimation. It is also important to estimate the predicted vital capacity of the subject for comparison to the measured value. A rough estimate of the vital capacity (VC) in liters can be calculated from the following formulas based on height (H) in centimeters and age (A) in years:

$$\text{VC (Male subject)} = (0.052H) - (0.022A) - 3.60$$

$$\text{VC (Female subject)} = (0.041H) - (0.018A) - 2.69$$

Because there are many other factors, besides height and age, that influence vital capacity, it should be assumed that measured volumes that are with $\pm 20\%$ of the predicted volume are considered normal.

Equipment Required

- PC Computer
- IWX/214 data acquisition unit
- USB cable
- IWX/214 power supply
- SP-304 Spirometer with plastic tubes
- FH-300 Spirometer flowhead
- Disposable mouthpieces

Equipment Setup

- 1 Place the IWX/214 on the bench, close to the computer.
- 2 Use the USB cable to connect the computer to the USB port on the rear panel of the IWX/214.
- 3 Plug the power supply for the IWX/214 into the electrical outlet. Insert the plug on the end of the power supply cable into the labeled socket on the rear of the IWX/214. Use the power switch to turn on the unit. Confirm that the red power light is on.

Start the Software

- 1 Click on the LabScribe shortcut on the computer's desktop to open the program. If a shortcut is not available, click on the Windows Start menu, move the cursor to **All Programs** and then to the listing for **iWorx**. Select **LabScribe** from the **iWorx submenu**. The LabScribe Main window will appear as the program opens.
- 2 On the **Main window**, pull down the **Settings menu** and select **Load Group**.

- 3 Locate the folder that contains the settings group, **Marieb-LS2.iwxgrp**. Select this group and click **Open**.
- 4 Pull down the **Settings menu** again. Select the **RespiratoryVolumes37A-LS2** settings file.
- 5 After a short time, LabScribe will appear on the computer screen as configured by the **RespiratoryVolumes37A-LS2** settings.
- 6 For your information, the settings used to configure the LabScribe software and the IWX/214 unit for this experiment are listed in Table 37A-1 on page 41. These settings are programmed on the **Preferences Dialog window** which can be viewed by selecting **Preferences** from the **Edit menu** on the LabScribe Main window.

Table 37A-1: Settings on the Channel Window of the Preferences Dialog Used to Configure the iWorx Recording System for Exercise 37A - Activity 5c.

Parameter	Units/Title	Setting	Mode/Function
Acquisition Mode		Chart	
Start		User	
Stop		User	
Display Time	Sec	10	
Speed	Samples/Sec	200	
Channel A4	Air Flow	✓	DIN8
Channel C1	Lung Volumes	✓	Vol.Human

Spirometer Setup

- 1 Locate the SP-304 spirometer, the FH-300 flow head, and the airflow tubing in the iWorx kit (Figure 37A-1 on page 41).
- 2 Firmly push the two air flow tubes onto the two outlets on the FH-300 flow head.
- 3 Firmly push the other ends of the two air flow tubes onto the two outlets on the SP-304 spirometer unit.



Figure 37A-1: The SP-304 spirometer, the FH-300 flowhead, and the airflow tubing.

42 Exercise 37A

- 4 Plug the DIN8 connector to the SP-304 spirometer into the Channel 4 input of the IWX/214 (Figure 37A-2 on page 42).



Figure 37A-2: A SP-304 spirometer connected to an IWX/214 unit.

Hints for Recording Good Data

- 1 Please read the procedures for each exercise completely before beginning the experiment. You should have a good understanding of how to perform these exercises before making recordings.
- 2 The spirometer will monitor breathing from a subject. It is important that the subject is healthy and has no history of respiratory or cardiovascular problems.
- 3 On the flow head, the outlets connected to the airflow tubing should always be pointed up to avoid problems with condensation developing within the tubing.
- 4 To reduce turbulence within the flowhead, place a disposable cardboard mouthpiece, that contains a screen, over the opening of the flowhead.
- 5 Use a clip to prevent air from entering or leaving the nose as the subject is breathing. Air that passes through the nose is not included in the volume measurements and causes errors in these values.

Calibrating the Equipment

- 1 The settings file, **RespiratoryVolumes37A-LS2**, programs LabScribe to record the breathing of the subject on the **Air Flow channel**. The computed function used on the **Lung Volume channel** converts the data recorded on the **Air Flow channel** to lung volume measurements.
- 2 Enter the calibration voltage of your SP-304 spirometer into the **Spirometry** computed function used on the **Lung Volume channel**:
 - Click on the words **Vol.Human (AirFlow)**, that are next to the title of the **Lung Volume channel**, to open the **computed function pull-down menu**.
 - Select **Setup** from this pull-down menu to open the **Spirometer Calibration Dialog window**.

- Enter the **calibration voltage**, that is listed on the label of your SP-304 spirometer unit, into the equation that sets the calibration voltage equal to one liter of lung volume.
- Make sure the **reset time** is set to **60 sec**, and the first **5 seconds** of the recording are used to zero the baseline of the **Lung Volume channel**. Click **OK**.

- 3 Allow the SP-304 to warm up for 10 minutes before recording for the first time.

Note: Do not hold the spirometer amplifier in your hand; the heat of your hand will alter the volumes recorded.

- 4 When spirometry data is recorded in the conventional manner, inhalation is always displayed as an upward deflection. To determine if the subject is breathing through the correct end of the flow head.

- Click on the **Save to Disk** button in the lower left corner of the **Main window** to switch the LabScribe software into **Preview mode**. When LabScribe is in **Preview mode**, there is a **red X** across the **Save to Disk** button. In **Preview mode**, the iWorx recording system works without recording data on the hard drive or any other storage media which allows a subject to become comfortable with breathing through a spirometer.

- Click on the **Preview** button. Have the subject inhale through the spirometer flowhead. Click on the **AutoScale** button at the upper margin of the **Air Flow** and **Lung Volume** channels. If the flowhead is oriented properly, the traces on the **Air Flow** and **Lung Volume** channels will go up during inhalation. If the traces on these channels go down during inhalation, have the subject breathe through the other end of the flowhead, or reverse the positions of the airflow tubes at the outlets of the flowhead.

Note: If the user clicks the Preview button and an error window appears the Main window indicating the iWorx hardware cannot be found, make sure the iWorx unit is turned on and connected to the USB port of the computer. Then, click on the OK button in the error window. Pull down the LabScribe Tools menu, select the Find Hardware function, and follow the directions on the Find Hardware dialogue window.

- 5 Click on the **Stop** button.

- 6 Before proceeding to the actual exercises, make sure the LabScribe software is set to **Record mode**. Click on the **Save to Disk** button, in the lower left corner of the **Main window**, to change LabScribe from **Preview mode** to **Record mode**. When LabScribe is in **Record mode**, there is a **green arrow** on the **Save to Disk** button.

Recording Data

- 1 Instruct the subject to sit quietly and become accustomed to breathing through the spirometer flowhead; breathe normally before any recordings are made; and, hold the flowhead so that its outlets are pointed up.
- 2 Instruct the subject to perform the following breathing in an unbroken pattern:

43 Exercise 37A

- Take three normal breaths (normal inhalations followed by normal exhalations).
 - At the end of the third normal exhalation, the subject should inhale as much air as possible, and then exhale normally.
 - Take three normal breaths.
 - At the end of a normal inhalation, the subject should exhale as much air as possible, and then inhale normally
 - Take three normal breaths.
- 3 Instruct the subject to remove the flowhead from his or her mouth and hold it at the mouth level in a position that prevents a breath from moving through the flowhead.

Note: The LabScribe software will zero the Lung Volume channel during the first five seconds of recording. No air should be moving through the flow head during this time.

- 4 Type <Subject's Name> Resting in the **Mark** box that is to the right of the **Mark** button.
- 5 Click on the **Record** button. After waiting five seconds for the **Volume** channel to zero, have the subject place the flowhead in his or her mouth and begin breathing. Press the **Enter** key on the keyboard to mark the recording.
- 6 Click the **AutoScale** buttons of the **Air Flow** and **Volume** channels. Notice the slowly moving wave on the **Volume** channel.
- 7 When the subject has completed the breathing pattern described in Step 2, click the **Stop** button to halt the recording. Your data may look like Figure 37A-3 on page 43.

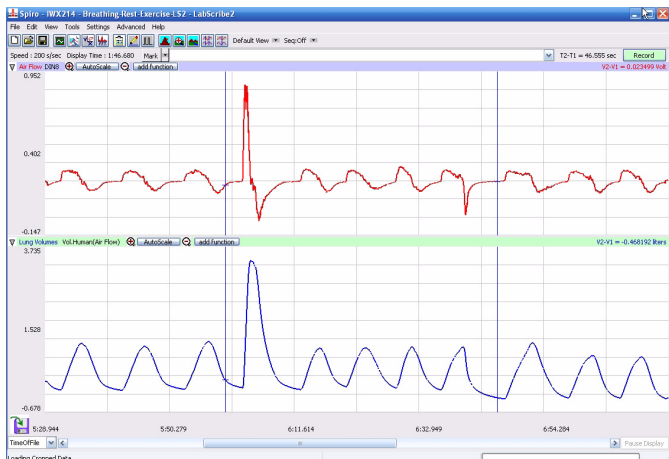


Figure 37A-3: Air flow and lung volumes of the normal and forced breathing of a subject at rest.

- 8 Select **Save As** in the **File** menu, type a name for the file. Choose a destination on the computer in which to save the file, like your lab group folder). Designate the file type as ***.iwxdata**. Click on the **Save** button to save the data file.
- 9 To record from another subject, select **New** under the **File** menu on the LabScribe **Main** window. Replace the flowhead and tubing with clean ones. Place a new mouthpiece on the flowhead. Repeat Steps 1 through 8.

Data Analysis

- 1 Scroll through the recording and find the section of data recorded when the subject was breathing normally.
- 2 Use the **Display Time** icons to adjust the **Display Time** of the **Main window** to show the complete breathing pattern on the **Main window**. The complete breathing pattern can also be selected by:
 - Placing the cursors on either side of the breathing pattern; and
 - Clicking the **Zoom between Cursors** button on the LabScribe toolbar to expand the complete breathing pattern to the width of the **Main window**.

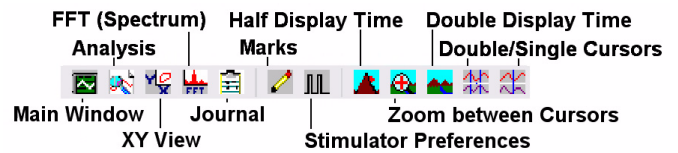


Figure 37A-4: The LabScribe toolbar.

- 3 Click on the **Analysis window** icon in the toolbar (Figure 37A-4 on page 43) or select **Analysis** from the **Windows** menu to transfer the data displayed in the **Main window** to the **Analysis window** (Figure 37A-5 on page 43).

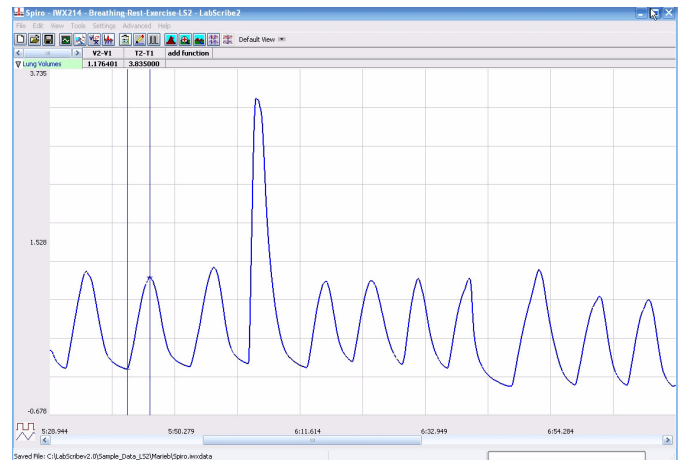


Figure 37A-5: Breathing pattern of a subject at rest, displayed on the **Volume** channel in the **Analysis** window. The cursors are positioned on the trough and the peak of the breath cycle to measure the tidal volume (TV) with **V2-V1** function.

- 4 Look at the **Function Table** that is above the uppermost channel displayed in the **Analysis** window. The mathematical functions, **V2-V1** and **T2-T1** should appear in this table. Values for **V2-V1** and **T2-T1** on each channel are seen in the table across the top margin of each channel.
- 5 Minimize the height of the **Air Flow** channel by clicking on the arrow to the left of the channel's title to open the **channel menu**. Select **Minimize** or **Hide** from this menu to reduce the height of the channel display or remove it from the on-screen display.

44 Exercise 37A

6 Maximize the height of the trace on the **Lung Volume channel** by clicking on the arrow to the left of the channel's title to open the **channel menu**. Select **Scale** from the menu and **AutoScale** from the **Scale submenu** to increase the height of the data on that channel.

7 Use the mouse to click on and drag the cursors to specific points on the recording to measure the **Tidal Volume (TV)**, which is the volume of air inhaled or exhaled during a normal breathing cycle:

- Place one cursor in the trough prior to inhalation.
- Place the second cursor on the peak of the inhalation.
- The value for the **V2-V1** function on the **Volume channel** is the tidal volume.(Figure 37A-5 on page 43).
- Record the value for the tidal volume in Table 37A-2 on page 44.

8 Repeat Step 7 on the other two tidal breaths recorded before the force inhalation.

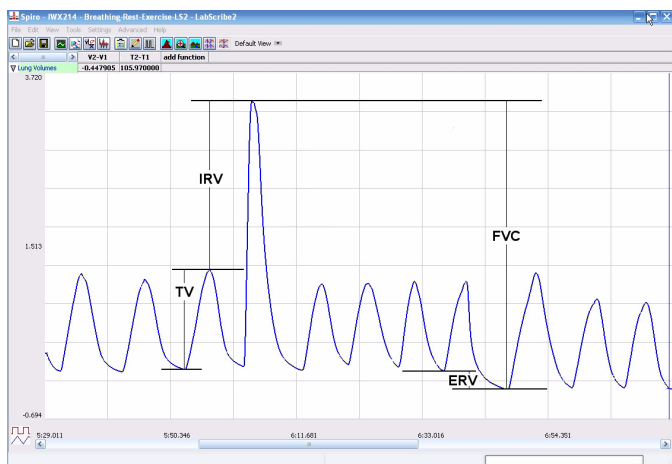


Figure 37A-6: Breathing pattern of a subject at rest, displayed on the **Volume channel** in the **Analysis** window. The labels and marks are placed in positions that indicate the pulmonary volumes of interest.

9 Average the three values obtained for the tidal volume and enter the mean in Table 37A-2 on page 44 and Table 37A-4 on page 44.

Table 37A-2: Average Tidal Volume from Normal Breath

	Breath 1	Breath 2	Breath 3	Mean
Tidal Volume (L)				

10 Use the mouse to click on and drag the cursors to specific points on the recording to measure the **Inspiratory Reserve Volume (IRV)**, which is the volume of air inhaled during a maximum inhalation:

- Place one cursor on the peak of the normal breath prior to the maximum inhalation.
- Place the second cursor on the peak of the forced inhalation.

- The value for the **V2-V1** function on the **Volume channel** is the inspiratory reserve volume.(Figure 37A-6 on page 44).
- Record the value for the inspiratory reserve volume in Table 37A-4 on page 44.

11 Use the mouse to click on and drag the cursors to specific points on the recording to measure the **Expiratory Reserve Volume (ERV)**, which is the volume of air exhaled during a maximum exhalation:

- Place one cursor on the trough preceding the normal breath prior to the maximum exhalation.
- Place the second cursor on the trough at the end of the maximum exhalation.
- The value for the **V2-V1** function on the **Volume channel** is the expiratory reserve volume.(Figure 37A-6 on page 44).
- Record the value for the expiratory reserve volume in Table 37A-4 on page 44.

12 Use the mouse to click on and drag the cursors to specific points on the recording to measure the **Forced Vital Capacity (FVC)**, which is the volume of air inhaled during a maximum inhalation:

- Place one cursor on the peak of the maximum inhalation.
- Place the second cursor in the trough of the maximum exhalation.
- The value for the **V2-V1** function on the **Volume channel** is the forced vital capacity (Figure 37A-6 on page 44).
- Record the value for the forced vital capacity in Table 37A-4 on page 44.

Table 37A-3: Lung Volumes for an Average-Sized Human Male (70kg).

Volumes	Volume (mls)
Tidal Volume (TV)	500
Inspiratory Reserve Volume (IRV)	3100
Expiratory Reserve Volume (ERV)	1200
Forced Vital Capacity (FVC)	4800
Residual Volume (RV)	1200

Table 37A-4: Pulmonary Volume Measurement

Volumes	Liters
Mean Tidal Volume (TV)	
Inspiratory Reserve Volume (IRV)	
Expiratory Reserve Volume (ERV)	
Forced Vital Capacity (FVC)	
Residual Volume (RV)	1.00 (assumed)

Questions**Table 37A-5: Calculated Pulmonary Capacities**

Capacity	Formula	Liters
Inspiratory Capacity (IC)	= TV + IRV	
Expiratory Capacity (EC)	= TV + ERV	
Functional Residual Capacity (FRC)	= ERV + RV	
Total Lung Capacity (TLC)	= TV + RV + IRV + ERV	

- Using the measurements in Table 37A-4 on page 44, calculate the capacities in Table 37A-5 on page 45.
- Use the formula in the introduction of this activity to calculate the predicted vital capacity of the subject, based on:

Height _____ cm; Age _____ years; Gender _____.

Predicted VC: _____ liters

- How does the measured vital capacity of the subject compare to the predicted vital capacity?
- Why might height and weight correspond to a subject's VC?
- What other factors might influence the VC of a subject?