

Lab #5: Spirometry

Materials Required: iWorx ETH-256 Bioamplifier with NI USB-6009 Interface; iWorx SP-304 spirometer and 300L pickup head; LabScribe Software

Introduction:

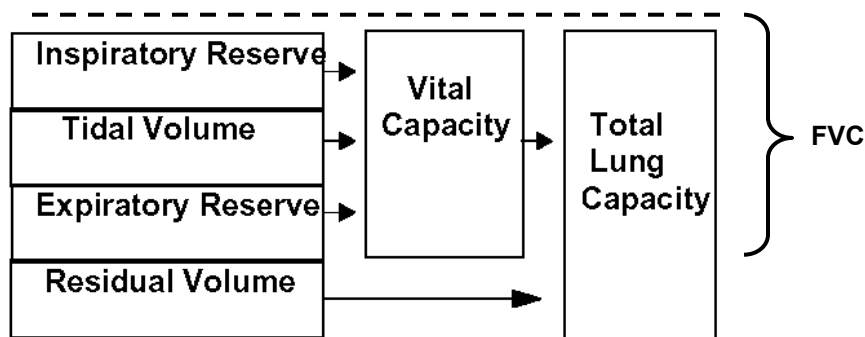
Spirometry is the measurement of the various air capacities and flows in the lungs. The practice is important in preventive and diagnostic medicine, and is often used in occupational health to screen employees for pulmonary trouble.

Measurements in Spirometry

There are several different volumes and flows that are measurable in humans. The following quantities are usually considered important:

- *Tidal Volume (TV):* The volume of gas inhaled or exhaled with each breath during NORMAL, resting breathing.
- *Expiratory Reserve Volume (ERV):* The maximum amount of air that can be exhaled after the tidal volume has been expelled. This volume always requires active expiration effort.
- *Inspiratory Reserve Volume (IRV):* The maximum amount of air that can be inhaled after the tidal volume has been inhaled. Requires extra effort.
- *Residual Volume (RV):* The volume of air remaining in the lungs after the deepest expiration possible.
- *Vital Capacity (VC):* The volume of air that can be exhaled after the deepest inhalation possible. $VC = IRV + TV + ERV$.
- *Forced Vital Capacity (FVC):* This is the workhorse of spirometry. It is the volume that can be expelled after a maximal effort.
- *FEV1 = Forced Expired Volume during first second of exhaling.* In a healthy individual it is at least 80% of FVC. ($FEV1\% = FEV1/FVC$)
- *Total Lung Capacity (TLC):* The total of the vital capacity and residual volumes. $TLC = VC + RV$.

Graphically, these relationships (with the exception of FVC, which is slightly smaller than TLC) appear like this:



In this experiment you'll observe and measure some of these quantities, and compare them to standards from the general population. From this information, you'll gain insight into the spirometry process, as well as some general information about your own pulmonary health.

Lab Procedure:

IMPORTANT: If you have a preexisting medical problem, see the instructor before your group attempts to record your spirogram.

1. Set up iWorx to measure the volume spirogram:

a) Connect the SP-304 spirometer to Channel 1. Connect the spirometer to the pickup head with the white paired tubing. (If there is a crimp in the tubing from packing, cut it off, since this may affect accuracy.)

b) Set the ETH-256 bioamplifier as follows:

Ch1: HPF=DC, GAIN=X1, LPF=50 Hz

Ch2: Not Used

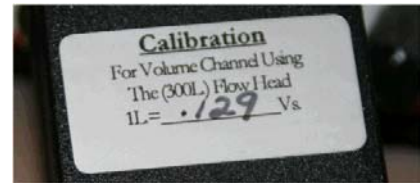
c) Start LabScribe and prepare it for recording:

- * Set the default configuration (Settings → Default)
- * Set the number of channels to 2 (Edit → Preferences → Channels)
- * Set the sample rate to 200 Hz.
- * Create a new document.

d) Calibrate LabScribe to the spirometer pickup:

- * Observe the calibration data given on the SP-304 unit:

For this unit, (at right), a flow of 1 L/s is represented as 129 mV dc output.



For Channel 1, you'd therefore tell LabScribe that $0.129 \text{ V} = 1 \text{ L/s}$ output. (Also, you should set the Channel 1 Ymax to +20 and Ymin to -20 L.) With the same information, you could also program LabScribe so that $1 \text{ V} = 7.752 \text{ L/s}$:

Channel Titles	Mode	Function	Ymax	Ymin	Raw	Cal	Unit
1 Channel 1	Record	Raw Data	20	-20	1 0	=> 7.809 => 0	L/s

It is CRITICAL that this calibration be performed correctly!

e) Program LabScribe Channel 2 to be the *INTEGRAL* of Channel 1. The integral of flow is volume, so Channel 2's units should be liters (L).

2. Perform a trial run to cancel the dc offset:

- a) Start the recording process. Do NOT disturb the pickup during this phase of the test.
- b) Carefully adjust the OFFSET control on Channel 1 until the reading is as close to zero as possible.
- c) STOP the recording, erase it (new document), and start a new recording.
Channel 2 should show ZERO volume with ZERO upward or downward drift.
- d) If there is any up or down drift on Channel 2, you have uncanceled dc offset. It doesn't take much! Carefully adjust the OFFSET control again and repeat these steps until the drift is corrected.

IT IS VERY IMPORTANT TO CANCEL THE DC OFFSET, SINCE IT IS AN ERROR TERM THAT ACCUMULATES OVER TIME.

3. Sterilize the pickup using a solution of 5% sodium hypochlorite (bleach), rinse thoroughly with fresh water, and dry using a hair dryer.

4. Record the tidal flow (TV) from a subject:

- a) The subject should hold the pickup in their mouth, and without pursing the lips, breathe normally through it. Make sure to use a nose clip.

Be sure to hold the pickup with the tubing facing up to prevent condensation from accumulating in the pressure tubes.



- b) Record a few seconds of this data.

→ Calculate and report the tidal capacity of the individual.

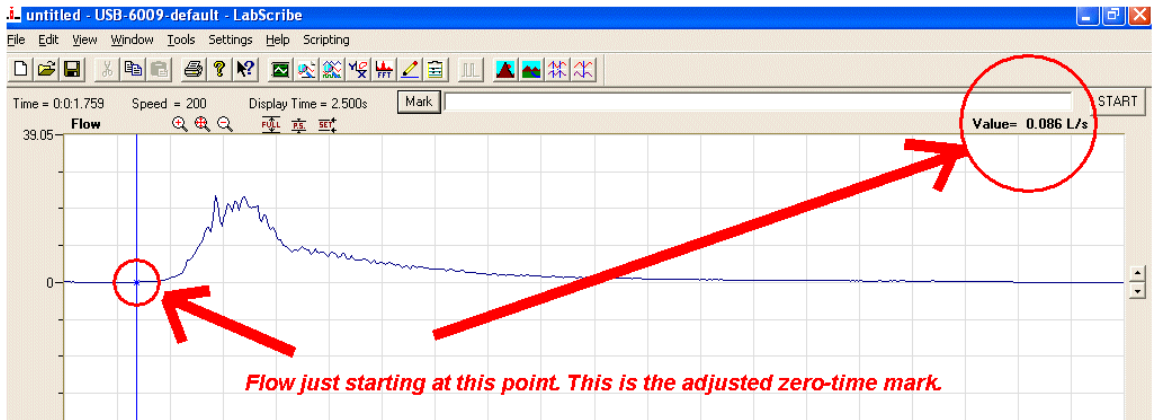
5. Record the FVC, FEV1, and FEV1% for the individual:

- a) The subject must wear a nose clip to get an accurate reading.
- b) Start the recording, making sure that there is no dc offset.
- c) Have the individual breathe in as deeply as possible, and then blow out as hard and fast as possible without pausing or stopping.
- d) Stop the recording.

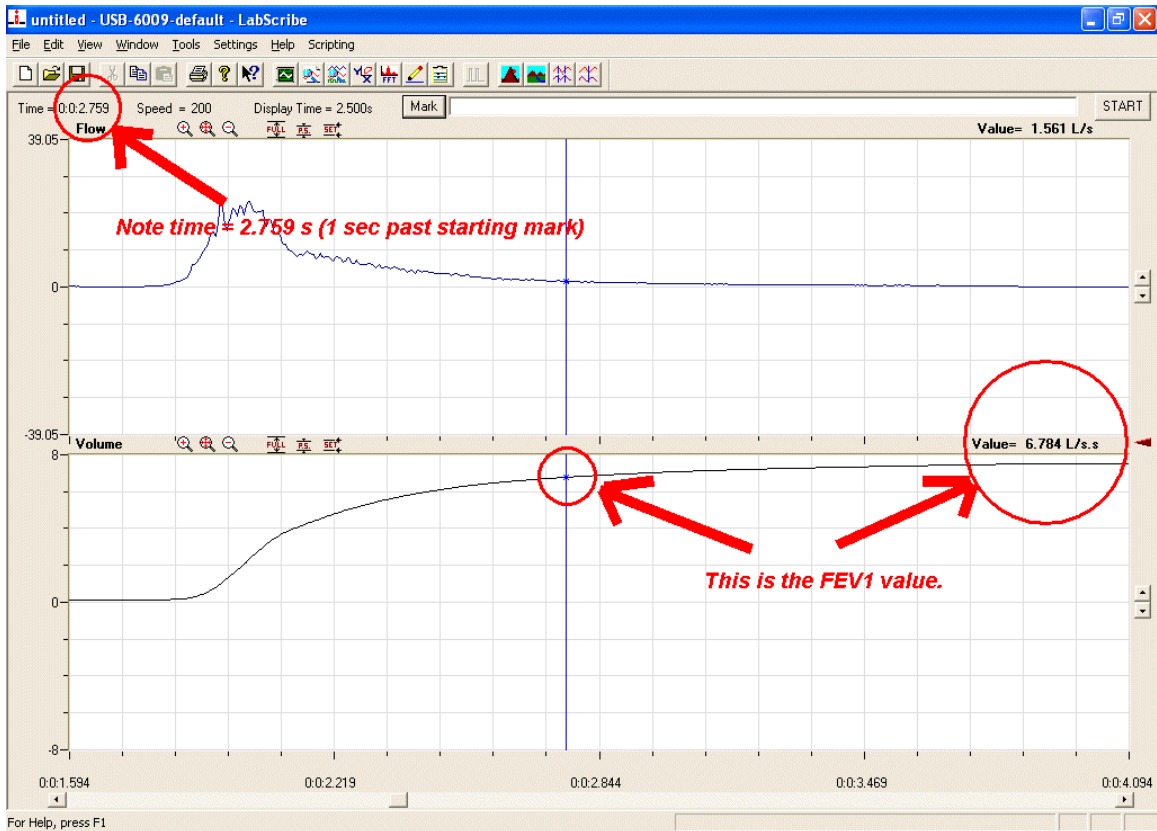
6. Examine the data recorded:

- a) The flow should be largely uninterrupted.
- b) To find FEV1, you must locate the time on the graph where significant expiration begins, then find the volume one second after this point. Use the single cursor to help.

IF YOU BEGIN AT THE ZERO ORIGIN ON THE GRAPH, YOUR FEV1 WILL BE INCORRECT!



7. Find FEV1 by moving the cursor one second past the zero-time mark you just found (in this example, it would be at $t=2.759$ s).



8. Validate the FVC and FEV1 values:

- a) Repeat the measurement.
- b) The two volumes (FVC) should be within 5% or 200 mL of each other.
- c) If the subject doesn't try as hard as he/she can to exhale each time, you will get highly variable results!

→ Report the validated FVC and FEV1 values for this subject.

→ Calculate FEV1%. [$FEV1\% = 100\% * (FEV1 / FVC)$]. Report the percentage. (It should be $\geq 80\%$ for a healthy individual.)

9. Compare the FVC and FEV1 values to the population estimate:

- a) Record the subject's age, sex, ethnicity, and height.
- b) Use the lookup table provided in the class notes to find the normal FEV and FEV1 values for persons "like" this individual.

→ Provide this data in your report.

10. Repeat the spirogram (Steps 3-9) for each person in your group. *Don't forget to sterilize the pickup between subjects.*

→ You need only provide *one* set of spiograms in your report (however, you may include them for all the subjects if you desire.)

11. Research Questions:

- a) Are there any individuals of similar background in your group but with significantly different spiograms? What could be the cause?
- b) For groups with male and female members, how did the FVC compare?
- c) Did any individuals in the group have an FEV1% less than 80%?

12. Before putting the kit away, please sterilize and dry the pickup again.