

Simulating Asthma

Asthma is a condition where a person's ability to breathe is impeded by a combination of inflammation of the airways (which causes swelling that narrows the passages) and excessive mucus production (which obstructs the passages). Asthma can be triggered by a number of things, including allergies, exercise, illness, stress, and even the inhalation of cold air. Asthma attacks are often accompanied by wheezing and coughing. Prolonged or severe asthma attacks can be life threatening, so asthma is typically treated as a serious medical condition.

Because asthma obstructs the airways, it becomes difficult to move air quickly during breathing. This results in a lowered flow rate for air moving in and out of the lungs. The peak expiratory flow rate, PEF, is the maximum rate of exhalation, and is typically measured by a peak flow meter, a small handheld device that patients can use to monitor their condition. Traditional spirometry doesn't usually examine PEF, but instead measures forced expiratory volume in one second, FEV₁, as part of a forced vital capacity test. Airflow obstruction is generally defined by a reduced FEV₁ to FVC (forced vital capacity), resulting in a relatively greater decrease in FEV₁, compared to FVC.

In this experiment, you will compare lung capacity when breathing normally and breathing with an obstruction that simulates asthma. You will also use flow loop analysis to compare FEV₁, and FVC between normal air movement and obstructed air movement. Unlike traditional spirometry, you will also measure PEF.

Important: The equipment used in this experiment is for educational purposes only and should not be used to diagnose medical conditions.

MATERIALS

Chromebook, computer, or mobile device
Go Direct Spirometer

Graphical Analysis 4 app

disposable mouthpiece
disposable bacterial filter

nose clip

tape

ballpoint pen or sharp pencil

PROCEDURE

Select one person from your group to be the subject. Important: Do not volunteer to be the subject if you are currently suffering from a respiratory ailment such as a cold or the flu.

Part I Vital Capacity

1) Launch Graphical Analysis. Connect Go Direct Spirometer to your Chromebook, computer mobile device.

2) Set up the data-collection mode.

a. Click or tap Mode to open Data Collection Settings.

b. Change End Collection to 60 s.

c. Click or tap Done.

3) Attach the larger diameter side of a bacterial filter to the "Inlet" side of the spirometer. Attach a disposable mouthpiece to the other end of the bacterial filter (see Figure 2). Important: The mouthpiece and bacterial filter must not be shared. If data are collected for multiple subjects, each person must have their own.

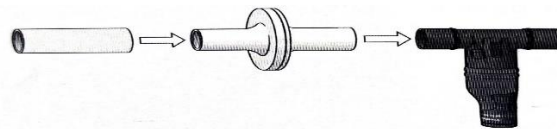


Figure 2

4) Zero the sensor.

a. Instruct the subject to hold the spirometer in one or both hands with the arm(s) braced against a solid surface, such as a table. The spirometer must be held straight up and down as shown in Figure 1. The subject should not breathe through the spirometer while it is being zeroed.

b. Click or tap the Flow Rate meter and choose Zero.

5) In this step, you will collect data. The spirometer is sensitive to the low air flow rates caused by moving the sensor, so it is important to follow the data-collection procedure carefully. Read through the following steps to become familiar with the process, and then collect data.

a. The subject should be seated comfortably and should put on the nose plug to ensure that he or she is only breathing through the mouth.

b. The subject should hold the spirometer in one or both hands with the arm(s) braced against a solid surface, such as a table. The subject should breathe normally, but should not start breathing through the spirometer until the next step. Note: The spirometer must be held straight up and down, as in Figure 1, and not moved during data collection.

c. On the subject's inhale, instruct the subject to start breathing through the mouthpiece and click or tap Collect to start data collection.

d. After 4 cycles of normal inspirations and expirations, instruct the subject to inhale as deeply as possible (maximum inspiration) and then exhale as fully as possible (maximum Expiration). It is essential that maximum effort be expended when performing tests of lung volumes.

e. The subject should continue breathing normally after the deep breath. Allow data collection to continue until you have collected data for at least one recovery breath after the deep breath, and then stop data collection.

Simulating Asthma

6) Determine tidal volume (TV).

- a. Identify a representative peak and valley in the tidal volume (TV) portion of the graph.
- b. Click or tap the peak and then drag to the valley that follows it.
- c. Click or tap Graph Tools, K, and choose View Statistics.
- d. Enter the Ay value, to the nearest 0.1 L., as the total tidal volume (TV) in Table 1.
- e. Dismiss the Statistics box.

7) Determine vital capacity (VC)

- a. Click or tap the peak that represents the maximum inspiration, then drag to the valley that follows .
- b. Click or tap Graph Tools, E, and choose View Statistics.
- c. Enter the Ay value, to the nearest 0.1 L, as the vital capacity (VC) in Table 1.
- d. Dismiss the Statistics box .

8) Determine inspiratory reserve volume (IRV).

- a. Click or tap the peak that represents your maximum inspiration and note the volume value.
- b. Click or tap the tidal volume peak just before maximum inspiration and note the volume value .
- c. Calculate the Ay value and record it, to the nearest 0.1 L, as the inspiratory reserve volume (IRV) in Table 1.

9) Calculate expiratory reserve volume (ERV) and enter the total to the nearest 0.1 L in Table 1

$$\mathbf{ERV = VC (IRV+TV)}$$

10) Calculate total lung capacity (TLC) and enter the total to the nearest 0.1 L in Table 1. (Use the value of 1.5 L for the RV.)

$$\mathbf{TLC-VC+RV}$$

11) Obstruct air movement to the spirometer

- a. Remove the disposable cardboard mouthpiece from the disposable bacterial filter.
- b. Cover the open end of the bacterial filter with tape until you have completely covered opening
- c. Carefully poke 5 to 7 holes in the tape using a pointed object such as a ballpoint pen or sharp pencil .
- d. Replace the disposable cardboard mouthpiece.

12) Repeat Steps 4-10 .

Part II Flow Loop Analysis

13. Set up the Spirometer and Graphical Analysis for flow loops

- a. Click or tap File, D, and choose New Experiment
- b. Click or tap Sensor Data Collection
- c. Connect to your Go Direct Spirometer
- d. In the list of Connected Devices, click or tap the Device Information icon (1) for your sensor. The Device Information dialog will open .
- e. Click or tap Advanced to expand the Advanced options.
- f. Set Volume inspiratory polarity to Negative. The other settings should remain at the default setting

Volume correction factor	1
Cycle volume source	Expiratory
Volume inspiratory polarity	Negative
Flow rate inspiratory polarity	Negative
Flow rate filter	5HZ
Data source	Live

- g. Click or tap Save to save your settings .
- h. Close the Device Information dialog box .
- i. Click or tap Done to view the graphs .

14) Set up the data-collection settings

- a. Click or tap Mode to open Data Collection Settings
- b. Change Start Collection to start data collection on a triggering event rather than manually .
- c. Then, adjust the triggering settings so that data collection starts when Flow Rate is increasing across 0.1 L/s and that 10 points are collected before trigger .
- d. Click or tap done

15) Click or tap View, H. and select Graph and Table. Then, click or tap the x-axis label and Select Volume to display a graph of flow rate vs. volume. Dismiss the box to view the graph.

16) Attach the larger diameter side of a bacterial filter to the "Inlet" side of the spirometer. Attach disposable mouthpiece to the other end of the bacterial filter (see Figure 1). Important. The mouthpiece and bacterial filter must not be shared. If data are collected for multiple subjects, each person must have their own .

17) Zero the sensor

a. Instruct the subject to hold the spirometer in one or both hands with the arms) braced against a solid surface, such as a table. The spirometer must be held straight up and down as shown in Figure 1. The subject should not breathe through the spirometer while it is being zeroed .

b. Click or tap the Flow Rate meter and choose Zero .

18) In this step, you will collect data. Read through the following information to become familiar with the data-collection process, and then collect data

a. The subject should be seated comfortably and should put on the nose plug to ensure that be or she is only breathing through the mouth. **Important:** It is essential that maximum effort be expended when performing tests of air flow. It is helpful for the subject to watch the screen while performing this test.

b. The subject should hold the spirometer in one or both hands with the arm) braced against a solid surface, such as a table. The subject should breathe normally, but should not start breathing through the spirometer until the next step. Note: The spirometer must be held straight up and down, as in Figure 1, and not moved during data collection .

c. Click or tap Collect to start data collection. Instruct the subject to take the deepest breath possible, put his or her mouth over the mouthpiece, and exhale forcefully as quickly as possible through the mouthpiece. The exhalation will trigger data collection. Without removing his or her mouth from the mouthpiece, the subject should then inhale as deeply as possible.

19) After data collection is complete, review the graph. If the graph does not approximate Figure 2. repeat data collection .

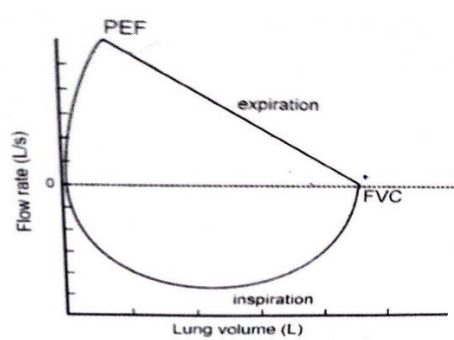


Figure 2

20) To find FEV1 , Scroll down the table in Graphical Analysis to 1.00's. Record the corresponding the volume value, to the nearest 0.01 L, in your data table

21) Click or tap any data point to examine the data pairs on the graph. As you click or tap each data point, the flow rate and volume values are displayed. Move the examine line to the right- most point of the flow volume loop. This is the FVC. Record the volume value, to the nearest 0.01 L, in the data table .

22) Find FEV1, /FVC, multiply by 100, and enter the calculated value in the data table .

23) Click or tap Graph Tools, and choose Statistics. Enter the maximum flow rate value to the nearest 0.01 L/s as peak expiratory flow rate (PEF) in the data table .

24) Obstruct air movement to the spirometer.

a. Remove the disposable cardboard mouthpiece from the disposable bacterial filter.

b. Cover the open end of the bacterial filter with tape until you have completely covered the opening,

c. Carefully poke 5 to 7 holes in the tape using a pointed object such as a ballpoint pen or sharp pencil

d. Replace the disposable cardboard mouthpiece.

25) Repeat Steps 17-23

26) Return the spirometer to default settings.

a. Click or tap Sensors

b. In the list of Connected Devices, click or tap the Device Information icon (1) for your sensor. The Device Information dialog will open.

c. Click or tap Advanced to expand the Advanced options

d. Set Volume inspiratory polarity to **Positive**. The other settings should remain at the default settings :

Volume correction factor	1
Cycle volume source	Expiratory
Volume inspiratory polarity	Negative
Flow rate inspiratory polarity	Negative
Flow rate filter	5HZ
Data source	Live

e. Click or tap Save to save your settings

DATA

Volume measurement	Unobstructed airway (L)	Obstructed airway (L)
Tidal volume (TV)		
Inspiratory reserve (IRV)		
Expiratory reserve (ERV)		
Vital capacity (VC)		
Residual volume (RV)	~1.5	~1.5
Total lung capacity (TLC)		

	FEV1 (L)	FVC (L)	FEV1/FVC (%)	PEV (L/s)
Unobstructed airway				
Obstructed airway				

DATA ANALYSIS

- 1) Describe how tidal volume (TV) and vital capacity (VC) changed between normal air movement and the simulated asthma condition in Part I of this exercise.
- 2) Describe how FVC and the FEV, changed between normal air movement and the simulated asthma condition in Part II of this exercise. Did they change proportionally from the normal condition to the simulated asthma condition?
- 3) Lung disease is often divided into two broad categories: obstructive disease and restrictive disease. Examples of obstructive disease are emphysema, chronic bronchitis, and asthma. Examples of restrictive disease are abnormalities of the spine and chest and diseases within the lungs that make them less elastic ("stiffer"), such as pulmonary fibrosis. Calculate the FEV1 /FVC in the table below for obstructive and restrictive disease and compare to your values. How might these values be helpful diagnostically?

Volume (L)	Normal (your data)	Simulated asthma (your data)	Obstructive disease	Restrictive disease
FVC (L)			4	4
FEV1 (L)			1.8	3.5
FEV1/FVC (%)				

EXTENSION

Patients with chronic or severe respiratory problems often develop additional complications if not treated. Have students research what causes these complications and explain the short-term and long-term consequences of chronic obstructive respiratory disorders.