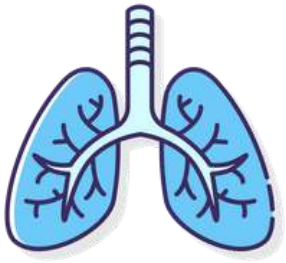
Air Pressure CO2



Breathing and Boyle's Law

Overview

Have you ever wondered how air gets into your lungs? Do we "suck" air in? Or does something else cause air to move? Today, we will discover that breathing is not about sucking air — it's about pressure differences.

Grades: Middle School
Time: 45 Minutes
Subject: Life Science & Physical Science
Topics: Respiratory System, Boyle's Law, Air pressure, Volume changes

Background

Breathing happens because of changes in air pressure inside your chest. Your lungs sit inside your chest cavity, and a large muscle called the diaphragm helps control breathing.

When the diaphragm tightens, it moves downward and makes more space inside the chest. When this space gets bigger, the air pressure inside the lungs becomes lower than the air outside your body. Air then moves into the lungs. This is called inhaling.

When the diaphragm relaxes, it moves back up and the space inside the chest gets smaller. The air pressure inside the lungs becomes higher than the air outside. Air moves out of the lungs. This is called exhaling.

This works because of a rule called Boyle's Law, discovered by Robert Boyle. Boyle's Law states that for a gas at a constant temperature, pressure and volume are inversely related. This means that when the volume of a gas increases, its pressure decreases. When the volume decreases, its pressure increases.

This physical principle explains how breathing works. The lungs do not actively pull air into the body. Instead, muscle movements change the volume of the chest cavity, which changes the air pressure. Air then moves automatically due to these pressure differences.

What You Will Need/Prep

- databot
- IOS/Android Smart Device
- 1 L plastic bottle
- 2 small balloons (9")
- 1 large balloon (12")
- Pneumatic tubing (5 mm)
- #4 two-hole stopper (or modified cap)
- Rubber bands
- Electrical tape, Velcro plate/strip
- Install Vizeey™ on your Smart device.
- Scan the QR code to load the experiment.
- Test your databot™ connection.
- You will be prompted to select and connect to databot™ each time you launch an experiment.
- Study the background information and terms and prepare to explore!

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Air Pressure CO2

In this investigation, you will build a working lung model and measure air pressure changes inside it using databot.
You will explore Boyle's Law, a scientific principle that explains how pressure and volume are connected, and see how this physical law controls every breath you take.

Learning Objectives

In this investigation you will master the following knowledge and skills:

- Visualize, collect and analyze data
- Build a functional lung model
- Measure air pressure changes during simulated breathing
- Interpret air pressure vs. time graphs
- Explain breathing using Boyle's Law
- Connect a scientific law to a biological system

Important Terms

Air Pressure: The weight of the air above us pressing down. We don't feel it normally because it is always there, but air has weight!

Boyle's Law: The law stating that pressure and volume of a gas are inversely proportional.

Diaphragm: A dome shaped muscle-membrane that separates your thorax from your abdomen. It plays a major role in breathing by contracting and changing the volume in your chest cavity which allows fresh air to rush in and deliver oxygen!

Exhale: To breathe out.

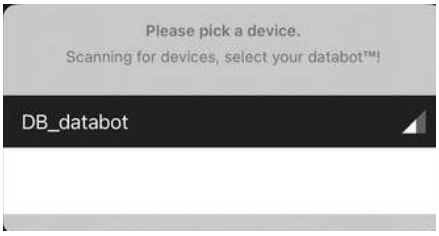
Inhale: To breathe in.

Respiratory System: your lungs, airway, and associated muscles, are responsible for breathing – taking in oxygen and expelling carbon dioxide.

Using Vizeey

In order to work with the experiment, you need to launch Vizeey application and click on + in the upper right corner.

Then select "Add experiment from QR code" and scan the QR code prepared for this experiment. Your experiment will appear in the list.



When you start the experiment you will be immediately offered to connect to your databot. Make sure that databot is enabled.

- If there are two or more databot's listed, the one closest to your device will be highlighted.

Part 1: Initial Observations and Questions

When you breathe in, does pressure inside your lungs increase or decrease?

_____

_____

What happens to pressure when volume increases?

_____

_____

Why does air move into your lungs?

_____

_____

Part 2: Hypothesis

Predict what will happen when the diaphragm (large balloon) is pulled downward. Write your prediction below.

_____

_____

Part 3: Experiment Procedure

Prepare:

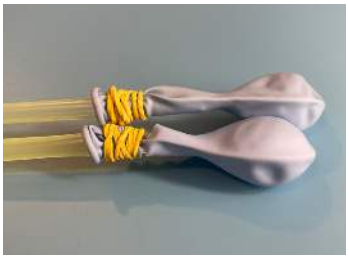
- databot
- 1 Liter plastic bottle – 1
- 9" Balloons – 2
- 12" Balloon – 1
- Pneumatic tubing (5 mm)
- Rubber bands
- Electrical tape
- #4 2-hole stopper (or modified cap)
- Velcro plate/strip



Part 3: Experiment Procedure

Setup

Refer to the pictures below to assemble your lung with databot™ inside!



Attach the 9" balloons to the pneumatic tubing. with rubber bands. These are the lungs.



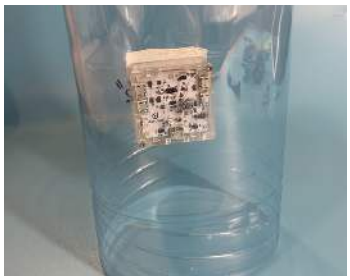
Slide pneumatic tubing with balloons into the #4 2-hole stopper. (You can use a bottle cap by making two holes in it for the tubes and then sealing them securely.)



Cut the bottom of your bottle (just above the ridge) and measure from the bottom up 3 1/2" and mark.



Attach the plate with the velcro to the inside of the bottle at the 3 1/2" mark with the ridges pointing to the bottom of the bottle. This is your diaphragm.



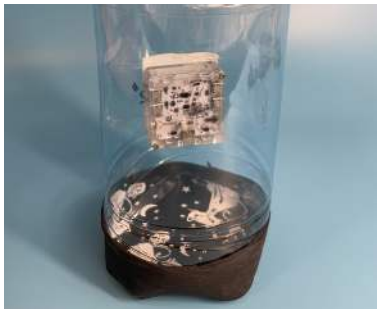
Slide databot on the velcro plate.



Cut your 12" balloon 2 1/2” from the top.



This is what your balloon should look like.



Stretch the balloon across the bottom of the bottle.



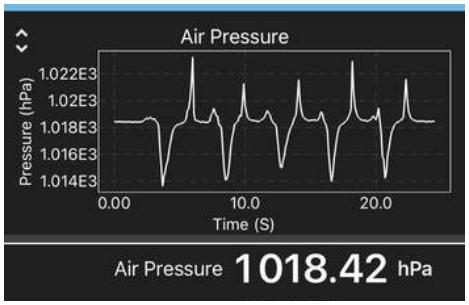
Use about 12" of electrical tape to secure the ballon to the bottle.



Insert the stopper with the balloons into the top of the bottle. Lungs done!

Part 3: Experiment Procedure

- Turn on your databot by gently squeezing your bottle and pressing the switch through the plastic.
- Tap on **Breathing** experiment in Vizeey.
  - Hint- if there is more than one databot in use, the one closest to you will be in blue!
  - A solid blue light on databot means you are connected.
- Start your data collection using ▶ .
- Record resting pressure in the table below.
- Now gently pull on the diaphragm:
  - This will increase the volume in the "chest cavity" and the higher pressure air outside the chamber will push in and fill the lungs.
  - You're simulating inhalation.
- Release diaphragm.
  - Observe balloons deflate.
  - You're simulating exhalation.
- Record pressure every 10 seconds.
- Watch the lungs and the data being displayed by databot as your model lungs breathe.
- Experiment with the diaphragm and practice breathing at 15 breaths per minute, that is a breath every four seconds.
  - Observe repeating air pressure patterns.



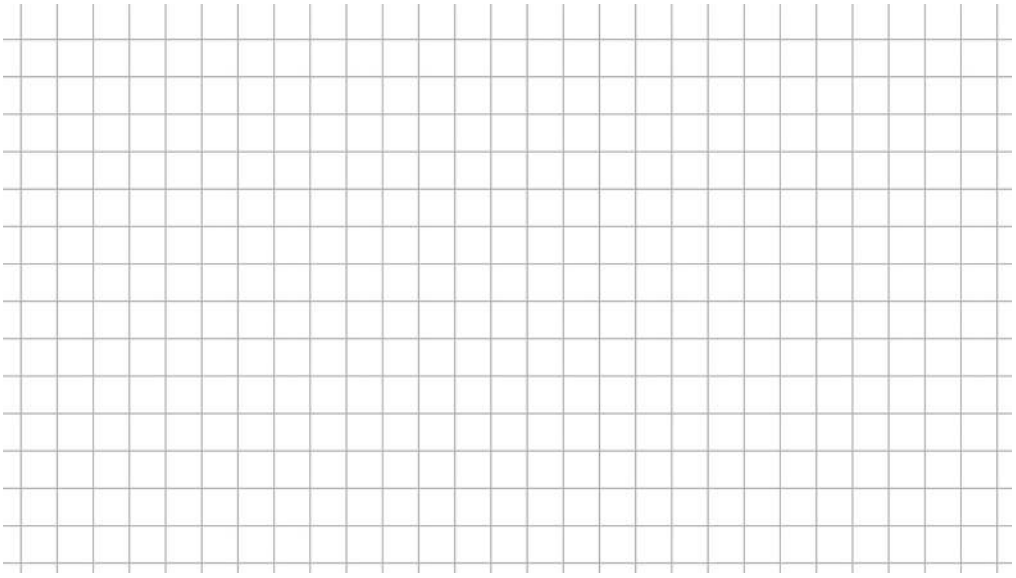
Data Collection Table

Time (s)	Action	Air Pressure (hPa)	Balloon Size
0	Rest		
10	Pull down		
20	Release		
30	Pull down		
40	Release		

Part 4: Data Analysis

Now that you have collected your data, it is time to analyze your results.

- Create a Pressure vs. Time graph.
- Identify:
  - Lowest and highest pressure. What does it correspond to?
- Describe pattern shape.
- Compare pressure values during:
  - Increased volume
  - Decreased volume



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Part 5: Concept Questions

1. What happened to pressure when volume increased?

2. What happened to pressure when volume decreased?

3. How does this demonstrate Boyle's Law?

4. Why does air move into the lungs when pressure drops?

5. What would happen if the diaphragm could not contract?

Part 6: Reflection

1. Were you surprised by how breathing actually works?

2. Did your data match your prediction?

3. How does Boyle's Law explain everyday breathing?

4. Why is understanding pressure important in medicine (e.g., ventilators)?