CO2

Sensor Starters

Grades: 4 & Up
Time: 15 Minutes -PDQ 1 & 2

Subject: Physics, Math, Data Science, STEM
Topics: CO2, CO2e, Air Quality, Respiration, ppm

Meet the CO2 Sensor!

CO2 sensors detect **carbon dioxide** levels in the air and are used in many applications including monitoring **air quality** levels in classrooms and confined spaces. High **CO2** levels are detrimental to learning and even dangerous if too high. These sensors are also used in automotive emissions monitoring and many other areas ranging from greenhouses to fire safety systems.

Background

CO2 is a colorless, odorless gas found in our atmosphere produced from breathing and from burning certain substances called fossil fuels. Most **CO2** in our atmosphere today comes from burning fossil fuels which people around the world are now taking action to reduce.

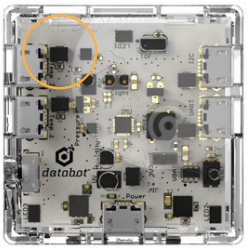
The **CO2** sensor on databot produces a **Carbon Dioxide Equivalent (CO2e)** value used to check the quality of air. The air we breathe provides oxygen and other essential components to fuel our cells and keep us healthy. High levels of **CO2** can **displace** oxygen(O2) and nitrogen (N2) causing health problems so it is essential to be able to monitor **CO2** to maintain good **air quality**.

The **CO2** sensor measures Ethanol and **Hydrogen** present in the air and calculates a **CO2e** level from these values.

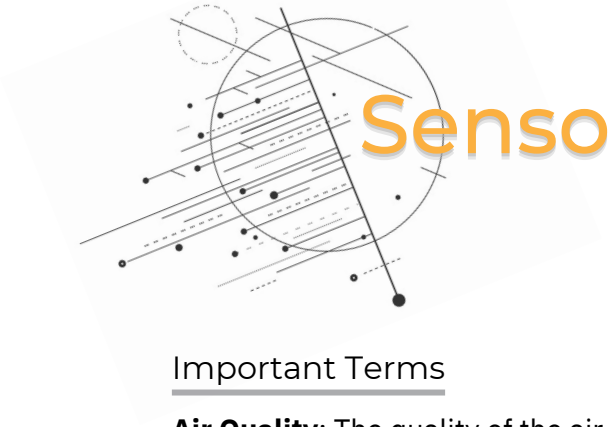
The **CO2** sensor has a sensing element known as a 'hot-plate' that detects **hydrogen**(H2) molecules present in the air. The microcontroller in the sensor reads this 'hot-plate' data and calculates **CO2** levels based on the trace **H2** molecules.

What You Will Need/Prep

- databot™ & Vizeey™
- IOS/Android Smart Device
- Use Vizeey to scan the QR Code for CO2.
- Ziploc Bag - 1 (quart)
- Straw - 1



*The **Air Quality/CO2** sensor is a black rectangular chip with a circle on it. Look for the label "Air" near the Temp 2 port on the databot PCB.*



Sensor Starters

Important Terms

Air Quality: The quality of the air that we breathe.

Carbon Dioxide (CO2): A colorless, odorless gas naturally present in the air you breathe.

Carbon Dioxide Equivalent (CO2e): A **CO2** value calculated from the presence of **Hydrogen**.

Displace: Take over the place, position, or role of someone or something.

Hydrogen: A chemical element. **Hydrogen** is the lightest element, easily the most abundant element in the universe.

Parts per million - (ppm): Usually describes the concentration of something in air, water or soil.

Respiration: The act or process of breathing - inhaling oxygen and exhaling **carbon dioxide.**

How do we measure CO2?

CO2 is measured in **parts per million** (**ppm**). The term **ppm** expresses the number of units (part) of a given substance that exists as a portion of a greater substance comprised of one million parts. **Parts per million** may be easier to understand if you see it as a fraction, here is an example of a **CO2** data reading of 670 **ppm**:

$$\frac{670}{1{,}000{,}000}$$

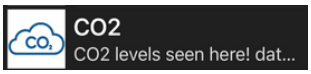
- The range of **CO2** that databot can detect is a low of 400 **ppm** and a high of 60,000 **ppm**.
- **CO2** is not harmful to humans however, it **displaces** oxygen which makes it dangerous in large quantities. If there is too much **CO2** in the air, it **displaces** the oxygen you need!
- The table below shows the kind of effect you can expect at different levels of **CO2** in **ppm**.

CO2 Levels	Effect
250-400 PPM	Normal background concentration in outdoor ambient air.
400 - 1,000 PPM	Concentrations typical of occupied indoor spaces with good air exchange.
1,000 - 2,000 PPM	Drowsiness and complaints of poor air.
2,000 - 5,000 PPM	Headaches, sleepiness and stagnant, stale, stuffy air. Poor Concentration, loss of attention, increased heart rate and slight nausea may also be present.
5,000 PPM	Workplace exposure limit in most places.
>40,000 PPM	Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.

Sensor Starters

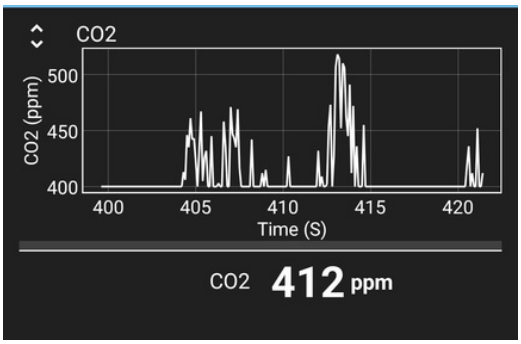
PDQ1 : Hunt for CO2!

Using the databot **CO2** sensor it is possible to monitor **air quality**. Your mission is to create a data table with your **CO2** levels and locations. Let's check for possible **air quality** danger!

- Open the Vizeey App on your smart device
- Turn on databot.
- Tap on "**CO2**" *in* Vizeey™ to load the experiment. 

- Hold databot in the palm of your hand.
- Start your and pause your experiments using . 
- Record the **CO2** levels in different locations on your data table.
- Between locations, stop and clear your data using.  before moving on to the next location.

*Sample **CO2** level in a room*



Location	CO2 Level

- Now, let's take this outside and measure the **CO2** levels in different environments. Try places like a garden area, terrace or near running and idle automobiles and record each **CO2** level and location in your data table.

- What areas tested have the highest level of **CO2**? Are any areas dangerously high?

CO2

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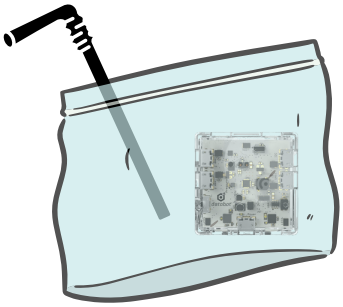
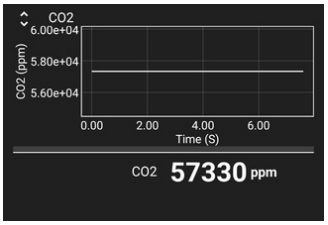
PDQ2 : Respiration & CO2

It's time to explore the human respiratory system with databot! Your mission is to compare **CO2** levels when breathing normally, after holding your breath, and after exercising - can you predict which one generates more **CO2**?



*Example **CO2** level*



- Open the Vizeey™ App on your smart device.
- Turn on databot.
- Tap on "**CO2**" *in* Vizeey™ to load the experiment.
- Place databot in the Ziploc bag with a straw.
  - Remove as much air as possible, and seal the bag except for the one corner with the straw.
- Start and pause your experiments using :
- Breathe in, then exhale gently into the bag through the straw.
  - The bag will inflate.
  - Remove the straw and seal the bag completely.
  - Record your **CO2** level on your data table.
- Stop the experiment
  - Clear the bag
  - Reset your data using.

Action	CO2 Level
Breathing Normally	
After Holding Breath	
After Exercising	

- Now, hold your breath for 30 seconds, and exhale gently into the bag through the straw, the bag will inflate. Remove the straw and seal the bag completely. Record the **CO2** level on your data table.
- Time to get your heart rate up! Do any kind of exercise for two full minutes like jumping jacks, running in place, hopping, etc. to get your heart rate up. Repeat the above experiment. Record the reading on your data table.

Do you we exhale more **CO2** when we are breathing normally, holding our breath or exercising? Was your prediction correct?

Check for Understanding

1. In your own words, explain **CO2** and its effect on humans.
2. What are some examples of how **CO2** sensors are used in the real world?
3. What are the units we use to express **CO2** levels in the air we breathe?

Standards & Alignment

NGSS Standards

- Earth's Systems (3-ESS2-2)
- Ecosystems: Interactions, Energy, and Dynamics (MHS-LS2-5)

Crosscutting Concepts

- Patterns
- Cause and Effect
- Energy and Matter

Disciplinary Core Ideas

- Weather and Climate (3-ESS2-2)
- Cycle of Matter and Energy Transfer in Ecosystems (MHS-LS2-5)

Science and Engineering Practices

- 1st Practice: Asking Questions and Defining Problems
- 3rd Practice: Planning and Carrying Out Investigations
- 4th Practice: Analyzing and Interpreting Data
- 5th Practice: Using Mathematics and Computational Thinking
- 7th Practice: Engaging in Argument from Evidence

ISTE Standards

- 1.1 Empowered Learner (1.1.d)
- 1.3 Knowledge Constructor (1.3.a)(1.3.b)(1.3.d)
- 1.4 Innovative Designer (1.4.a)(1.4.b)
- 1.5 Computational Thinker (1.5.a)(1.5.b)
- 1.6 Creative Communicator (1.6.a)(1.6.b)

TEKS -Texas Essential Knowledge and Skills

Middle School Process TEKS

7.2E Scientific investigation and Reasoning: Analyze data to formulate reasonable explanations
8.2A Scientific investigation and Reasoning: Plan and implement comparative and descriptive investigations

Middle School Level Content TEKS

6.9C Force, Motion, and Energy: Demonstrate energy transformations
8.11B Organisms and Environments: Explore how short- and long- term environmental changes affect organisms

High School Level Process TEKS

B.2F: Scientific Investigation and Reasoning: Collect and organize qualitative and quantitative data and make measurements with accuracy and precision, using tools such as data collecting probes.

High School Level Content TEKS

B.4B Biology: Investigate and explain cellular processes.
B.10A Biology: Describe the interactions that occur among the systems that perform the functions of regulation.

Standards & Alignment: Australian National Curriculum

Science

- Science Understanding (Biological Sciences)
  - ACSSU150: "Energy appears in different forms, including movement (kinetic energy), heat and potential energy, and causes change within systems."
  - ACSSU175: "Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment."
- Science Understanding (Chemical Sciences)
  - CSSU225: "The properties and behaviour of substances can be explained in terms of the motion and arrangement of particles."
- Science Inquiry Skills
  - ACSIS154: "Pose questions and hypotheses that can be investigated scientifically."
  - ACSIS155: "Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data."
  - ACSIS157: "Use appropriate scientific language and representations to communicate science ideas, methods, and findings in a range of text types."
  - ACSIS231: "Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data."
  - ACSIS232: "Organise data in tables and graphs to identify and describe patterns and trends, and to draw conclusions."
  - ACSIS233: "Use knowledge of scientific concepts to draw conclusions that are consistent with evidence."

Mathematics

- Measurement and Geometry
  - ACMNA192: "Convert between common metric units of length, mass and capacity."
- Number and Algebra
  - ACMNA132: "Compare fractions with related denominators and locate and represent them on a number line."
  - ACMNA133: "Solve problems involving the comparison of fractions, including using visual representation."

Health and Physical Education

- Personal, Social, and Community Health
  - ACPPS070: "Investigate the role of preventive health in promoting and maintaining health, safety, and wellbeing for individuals and their communities."

Critical and Creative Thinking

- Critical and Creative Thinking
  - ACTDIP042: "Investigate, analyse and synthesise information and ideas from a range of sources in response to or for a specific purpose and audience."