Explore the Ideal Gas Laws with Code

The pressure a gas exerts on its container is the result of millions of tiny collisions between the gas molecules and the walls of the container. Each minute collision is insignificant. But taken together, the combined force of those millions of collisions produce a pressure we can feel and measure.

Analyzing the force of a single molecular collision is fairly simple. Multiplying that analysis ten, twenty, or a hundred times is tedious—a perfect job for a computer! Let's explore a simulation of a gas in a container.
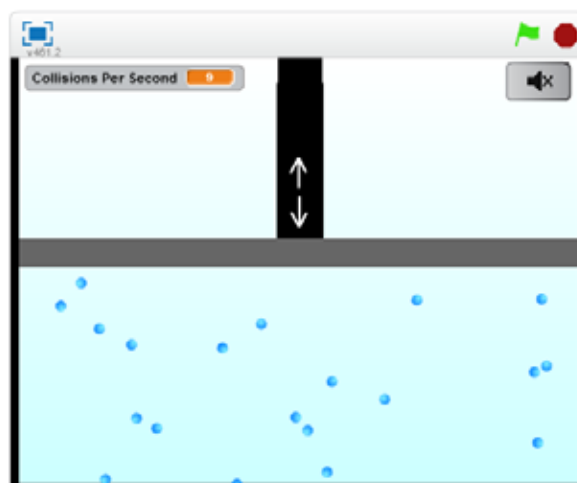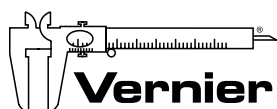
Ideal Gas Law Simulation in Scratch

Figure 1 Ideal Gas Law Exploration project in Scratch

1. Open this Scratch project: https://scratch.mit.edu/projects/265158104/
2. Click the green flag icon in the upper-right corner of the image to start the simulation.
3. Each blue circle represents a gas molecule. There are two ways to sense the gas's pressure on the container:
   a. The number of collisions between the molecules and the four walls of the container is displayed in the upper-left once a second. The greater the number of collisions per second, the greater the gas pressure.
   b. Each collision creates a "boing" sound. The faster you hear boings, the greater the pressure.
      Note: Click on the volume button in the upper-right to turn the sound on and off.
4. Press the up or down arrow keys to move the piston, which forms the top surface of the container. How does the gas pressure change as you decrease the volume of the container?

Explore the Code to See How the Simulation Works

This simulation is the result of some simple code. Click the "See inside" button on the project page to launch the Scratch editor and see how it works.

The simulation is consists of three Sprites, each controlling one aspect of the simulation. Click on each Sprite, located in the lower-left of the Scratch editor window, to see the code that controls that Sprite. The Piston and Sound Button sprites generate the Counts Per Second value and the boing sounds. Most of the action (and science!) happen in the Molecule sprite. Its code consists of four functions:

Creating the Molecules

This function creates simply creates the molecules in the container by "cloning" itself a specified number of times.

Figure 2 Creating the molecules by cloning the Molecule sprite

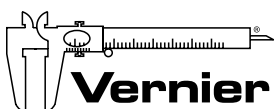## Bouncing Around the Container

Once molecules are cloned/created, this function tells them what to do: jump to a random position, point in a random direction, and then bounce around.

Figure 3 How the cloned molecules will behave

How to Bounce off a Wall

Of course, the molecules don't know how to bounce around without some code. This function tells them exactly how to bounce.

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13979 SW Millikan Way   Local   503-277-2299   www.vernier.com
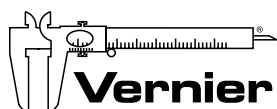Beaverton, OR 97005-2886   Fax   503-277-2440

What Happens if an Molecule Escapes

Our bouncing code isn't perfect though. Occasionally a molecule manages to escape past the Piston. This code deletes those rogue molecules and creates a new one on the correct side of the piston.

Change the Code to Explore Number of Molecules and Molecular Speed

How does the gas pressure change as you change the number of molecules in the gas? Its temperature? You can change these quantities in the simulation code by change the number of times the Molecule sprite clones itself and by changing the molecules speed. Try it out! Comments in the code (not included in the images above) explain which values to change.

Teacher Information
Explore the Ideal Gas Laws with Code

Overview

Computer simulations are used in scientific research to test the results of possible relationships between the quantities under investigation; if the simulation matches real world outcomes, the proposed relationships are likely correct! In this activity, students interact with a simulation of a gas in a container to explore the ideal gas laws.

Objectives

- Look "under the hood" in a computer simulation to see how it works
- Modify the code to change the simulation and explore how it changes the "measured" gas pressure
- Gain an appreciation for how computer simulations provide insight into scientific models
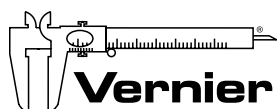
CSTA Standards

1B-AP-12	Modify, remix, or incorporate portions of an existing program into one's own work, to develop something new or add more advanced features.
2-DA-09	Refine computational models base on the data they have generated.

Materials

Windows or macOS computer with Scratch-compatible browser installed

Tips

1. Before doing this activity, verify that Scratch will run on the student computers and browsers. Scratch requires Flash to be enabled before it will run within a browser. Often school computers/browsers are set to automatically disable Flash; manually enabling Flash would be required before Scratch will run.
2. Students that have used Scratch before will very quickly move through this activity. Encourage them to modify any of the sprites in the simulation.
3. If students want to save their modified simulations, they can do the following:
    a. Download it by choosing "Download to your computer" from the File menu.
    b. Log into their Scratch account and choose "Remix" from the project page.