Name____________________ Section__________ Date________

CONCEPTUAL PHYSICS: Hewitt/Baird | **Tech Lab**

Heat, Temperature, and Expansion — Kinetic Theory Simulation

Bouncing Off the Walls

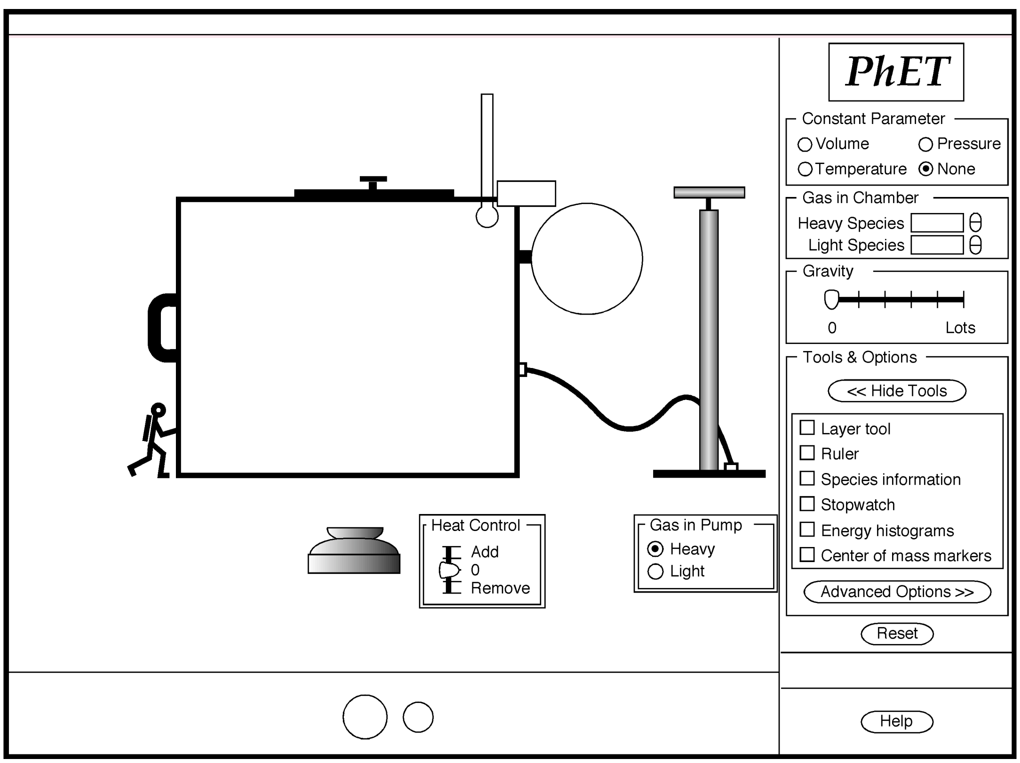
Purpose
To control and observe the behavior of gas particles (atoms or molecules) as modeled in a simulation to investigate properties of gas such as temperature and pressure

Apparatus
computer — PhET simulation: "Gas Properties" (available at http://phet.colorado.edu)

Discussion
Kinetic molecular theory explains the large-scale characteristics of gases in terms of the behavior of the atoms and molecules that make up the gas. The Gas Properties simulation lets you see the individual particles in motion. It gives you control of a chamber of gas and lets you see the effects of the changes you make.

Setup
Step 1: Start the computer and login. Open the PhET simulation, "Gas Properties."

Step 2: In the on-screen control panel, click the Measurement Tools button.



Step 3: Add labels to the figure above for each item listed below.

Thermometer	*Pressure gauge*	*Heat source/sink*	*Gas pump*
Chamber lid	*Play/pause*	*"Scubie" (the volume adjuster)*	

More curriculum can be found in Pearson Addison Wesley's **Conceptual Physics Laboratory Manual: Activities · Experiments · Demonstrations · Tech Labs** by Paul G. Hewitt and Dean Baird. ISBN: 0321732480

Procedure

PART A: SIMULATION MECHANICS
Remember that any time you need to, you can use the on-screen reset button to return to the initial setup.

Step 1: Determine two distinct methods by which you can add particles to the chamber.

a. Method 1: Use the pump. How do you manipulate the pump handle to get the *greatest* number of particles into the chamber in ***one*** stroke?

b. Describe Method 2: How can you ***precisely*** control the number of particles injected into the chamber? (Method 2 does not involve direct use of the pump.)

Step 2: How can you release particles from the chamber (***without*** breaking the chamber)?

a. Method 1:

b. Method 2 (*completely* different from Method 1):

Step 3: How can you add heat to the gas? How does the simulation illustrate this?

Step 4: How can you remove heat from the gas? How does the simulation illustrate this?

Step 5: How can you compress the gas (decrease its volume)?

Step 6: How can you expand the gas (increase its volume)?

PART B: THE NATURE OF THE IDEAL GAS LAW

Step 1: What happens to the pressure in the chamber if you heat the gas?

Step 2: What happens to the temperature in the chamber if you compress the gas?

Step 3: Locate the "Constant Parameter" section of the on-screen control panel. Lock the temperature. Use "Scubie" to slowly compress the gas. What happens to temperature, and what action is taken (by the simulation) to maintain constant temperature?

Step 4: Lock the pressure. (Doing so releases the lock on temperature.) Add heat. What happens to pressure, and what action is taken (by the simulation) to maintain constant pressure?

PART C: ALL SPECIES GREAT AND SMALL

Create a chamber in which there is a mix of 50 light and 50 heavy gas particles. In the on-screen control panel, activate "Species Information."

Step 1: Consider the species information and the meaning of temperature.

a. Which species—if either—has the greater average speed?

b. Does the temperature in the chamber reflect the average speed, momentum, potential energy, or kinetic energy of the particles? And how does this explain your finding in Step 1. a.?

Step 2: Reset the chamber to have about 100 heavy particles. The temperature should be 300 K. Click the on-screen button to activate the "Center of mass markers."

a. Consider the statement, "The average *speed* of air molecules in a room may be over 1000 mph (400 m/s) while their average *velocity* is approximately zero." The particles in the simulation's chamber are modeling the air molecules in a room. Cite evidence from the simulation to confirm or reject the quoted statement.

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b. What is the name of the condition when the average velocity of atmospheric molecules around you is not zero? (Hint: It's a common four-letter word starting with the letter "W.")

Going Further

1. Under what specific condition will the lid be blown off the chamber? Is it possible to blow the lid with just one particle in the chamber?

2. Is it possible to achieve a six-figure temperature? If so, how? If not, what's the highest temperature you could achieve?

3. As of 2010, low-temperature physicists have not been able to cool anything to a temperature of absolute zero (0 K).

a. Cool a simulated 50/50 sample (50 light and 50 heavy particles) gas sample to absolute zero.

b. When the temperature hits absolute zero, are the particles shown to be at rest?

4. Use Scubie and the ice (Heat Control: Remove) to compress and cool a 50/50 sample to the smallest volume possible and to absolute zero. Now use Scubie to rapidly expand the volume of the chamber all the way out. Describe what happens. And which species wins the race to the far side of the chamber (where Scubie is)?

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