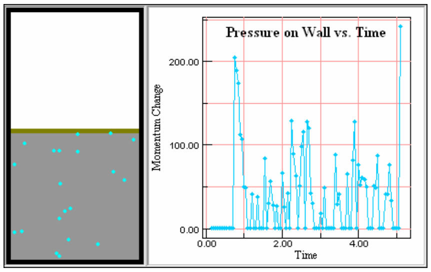
Worksheet for Exploration 20.3: Ideal Gas Law



The relationship between the number of particles in a gas, the volume of the container holding the gas, the pressure of the gas, and the temperature of the gas is described by the ideal gas law: PV = nRT. **In this animation N = nR** (i.e., k_B = 1). This, then, gives the ideal gas law as PV = NT. Restart.

Notice what happens as you change the number of particles, the temperature, and the volume. The pressure is due to collisions with the walls of the container. The graph shows the instantaneous "pressure" (the change in momentum of the particles as they hit the wall and thus exert a force) as a function of time, while the table shows both NT/V (equal to the pressure for an ideal gas) and the average of the instantaneous pressure.

a. Keep the number of particles and the volume constant. What happens to the speed of the particles as the temperature changes? What happens to the pressure (N*T/V) if you increase the temperature? (this is known as Gay-Lussac's Law: P/T = constant)
   i. Complete the table for several temperatures.

T	P

b. If you double the volume (while keeping the same number of particles and the same temperature), what happens to the pressure (and force on the wall)? Why? (This is known as Boyle's law: PV = constant.)
   i. Complete the table.

V	P

c. If the number of particles is increased (and the temperature and volume stay the same), what happens to the pressure (and the force on the wall)? Why?

N	P

d. If you double the volume and halve the temperature (while keeping the number of particles constant), what happens to the pressure? (This is known as Charles's Law: V/T = constant.)

Note that all of these "named" gas laws are included in the ideal gas law: PV = nRT.

You can also drag the top of the piston to change the volume. In this process, both the temperature and pressure can change.

e. Start with a volume of 100. Drag the piston up. What changes and why?

f. Once the particles have spread out into the entire volume available, drag the piston back down. Notice that the particles move fast and the temperature and pressure change dramatically. This is because as the piston comes down and particles hit it, the downward moving piston transfers some of its momentum to these particles and so they speed up. Faster moving particles mean a higher temperature. In a real system, you would not normally see this effect because the particles are moving much faster than any piston being compressed (but if they moved that fast in the animation, you wouldn't see individual particles).

g. How would you need to drag the piston to minimize the change in temperature? Start with a volume of 100 and temperature of 100 again and try to minimize the increase in temperature as you compress the piston.