Experiment #1
Atmospheric Pressure

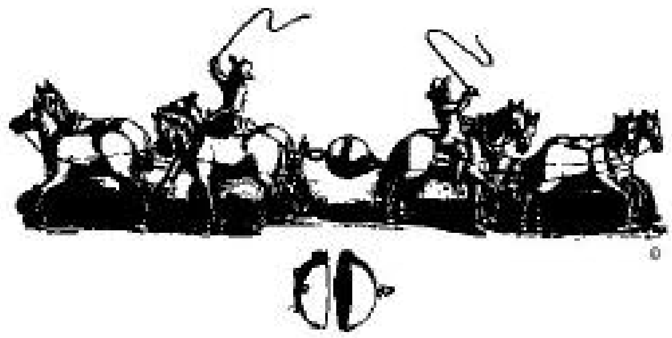
The earth is surrounded by a mixture gases referred to as the "atmosphere".
It extends from the surface to approximately 1000 km, with most of the atmosphere below 10 km. The composition of the atmosphere is primarily nitrogen (78%) and oxygen (21%). The remaining one percent contains Ar, CO_2, Ne, He, Kr, Xe, CH_4, and H_2.

All gas molecules in the atmosphere are in constant motion, undergoing millions of collisions with other gas molecules or surrounding surfaces every second. At room temperature and normal atmospheric pressure, one cubic foot (0.03 cubic meter) of air contains approximately $7x10^{23}$ molecules moving in random directions at speeds of around 1,000 miles per hour (1,600 kilometers per hour).

The average distance a gas molecule travels before it collides with another gas molecule is referred to as its **mean free path**. At atmospheric pressure the mean free path is extremely short, about $6x10^{-5}$mm (0.00006 mm). The result of these collisions is **atmospheric pressure** exerted on all surfaces surrounding the gas molecules. At sea level and 25^{o}C the atmospheric pressure is approximately 100,000 Newtons per square meter (1 Pascal) or 14.7 pounds per square inch. An atmosphere (atm) is defined as the pressure exerted by a 760 mm column of mercury having a specific gravity of 13.595 g/cm3(at 0^{o}C).

The model that describes the behavior of gases is known as the **kinetic theory of gases**. One of the main assumptions of the kinetic theory of gases is that gas molecules are in constant motion and thus have kinetic energy. The velocity at which a gas molecule travels is dependent on the square root of its temperature and inversely proportional to the square root of its mass.
Thus large molecules travel slower than small molecules and molecules leaving a hot surface travel faster that those leaving cold surfaces.

One of the first recorded attempts to measure atmospheric pressure was Otto von Guericke's famous Magdeburg hemispheres experiment in 1672. In this experiment von Guericke tried to separate two evacuated hemispheres with two teams of horses.



If : FORCE = pressure x AREA

1 Determine the "ideal" force required for von Guericke's horses to overcome atmospheric pressure on a set of hemispheres with a cross section of 21.6 inches. Assume that the atmospheric pressure was 760 mm of mercury.

a Does the shape of the hemispheres make a difference?
Will the actual force required to separate the hemispheres be the same as the ideal force? If not, why?

b Why were two teams of horses used?
Would not one team prove the point just as well?

2 To demonstrate the force exerted by atmospheric pressure use a small suction cup (like one used to hold pictures, kitchen utensils, etc. on a wall)

a Attach it to the underside of a convenient surface.

Calculate how much weight suspended from the suction cup it would take to separate it from the surface.

b Add weight until it separates.

c Is the amount of weight required to separate the suction cup equal to the calculated amount? If not, why is there a difference?

3. Does water boil at a lower or higher temperature in Denver, Colorado compared to Miami, Florida?
Why?