Mind Trekkers

Expanding Peeps! Lesson Plan

Amount of time demo takes: 3-5 minutes

Materials:
1. Vacuum canister and pump (pictured right)
2. A readily-expanding material to put within the canister.
   Suggestions: Peeps, marshmallows, shaving cream, balloons, or whipped cream
3. Rags or Clorox wipes to clean out equipment
4. Magdeburg Hemispheres (2)

Set up instructions and instructional procedure:
1. Set out the canister, inviting students to pick which item they’d like to expand.
2. After placing the item inside, put the lid on. Ensure that it is sealed tightly and completely!
3. Place the bottom of the pump over the grey seal in the middle of the lid. Being careful to keep the pump vertical, quickly pump out as much air as you can from the container.
4. Have the students observe what is happening, ask if they have an explanation, and talk with them about it (see below).
5. At the end of the demonstration, press in on the button to let air back into the canister. Observe what happens to the expanded material.

SAFETY! -- Safe demo!

Lesson’s big idea
● In short: this is another of our demonstrations that illustrates gas laws and the power of air pressure, specifically how the atmosphere that surrounds us constantly keeps us from exploding!. On any given item, there are 14.7 pounds per square inch pressing on it at all times. When we use the pump to remove the air from the canister, we are creating a vacuum, in which there is significantly less air pressure. Without the pressure, the Peep grows.
● In more depth: Gases follow what is called the Ideal Gas Law. This law states that in a given system, \( pV = nRT \). Let’s break this equation down:
  - \( p \) = pressure of the gas (Pascals, Pa)
  - \( V \) = volume of the gas (cubic meters, m\(^3\))
  - \( n \) = the number of moles of gas (more loosely, how much gas there is)
  - \( R = 8.31 \) J/mol K, the universal gas constant
  - \( T \) = the temperature of the gas (Kelvin, K)
When we use the pump to suck air out of the system, the value we are reducing is \( n \), the amount of gas inside the chamber. The right-hand side of our equation is getting smaller. To keep the equation (and our system) balanced, the pressure, \( P \), decreases inside the canister. Volume can’t decrease -- the container isn’t shrinking -- so to make up for the removed air, pressure decreases and our Peep expands!

Upon pressing the button on the lid, air is let back into the container -- \( n \) increases, \( R, T \), and \( V \) once again stay largely unchanged, and \( P \) is left to increase. The Peep squashes back down to his original size under 14.7 psi.

**Addition: Magdeburg Hemisphere**

1. Take the two hemispheres and push them together.
2. Challenge a spectator to pull the hemispheres apart by grasping the handles and pulling straight outward.

**How it works:**
When the hemispheres are pressed together air is forced out of the interior creating at least a partial vacuum. This seals together the hemispheres with a remarkable force. When air is removed from the interior of the hemispheres, there is no longer any force pushing outward and the atmospheric pressure outside dominates, pushing the hemispheres together and keeping them from being easily separated.

**Assessment**
Why does the Peep expand?
Why do solid objects not expand so noticeably?
What quantity did we change to reduce pressure inside the system?
How much air pressure is pushing on you all the time?

**Clean Up**
Thoroughly clean out the canister and lid to remove sugar, shaving foam, etc. Place the Magdeburg Hemispheres in a plastic bag to prevent them from drying out. Neatly package any materials that can be used for later demonstrations, and let someone know if a supply has run out.

**References**
Physics for Scientists and Engineers by Randall D. Knight (p. 452-458)