Marshmallow Man Meets the Vacuum Pump

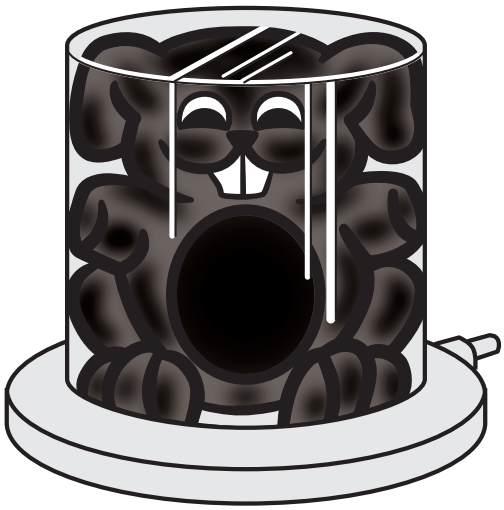
A Boyle's Law Activity

Introduction

Boyle's Law made easy! Amaze your students by expanding a marshmallow figure in a vacuum chamber!

Concepts

- Boyle's Law
- Inverse pressure/volume relationship



Materials

Beaker

Marshmallow bunny or chick, or marshmallow stick-man

Vacuum chamber with plate

Vacuum pump, two-stage

Vacuum tubing

Safety Precautions

Any food-grade items that have been brought into the lab are for lab use only. Do not taste or ingest any food in the lab and do not remove any remaining food items. Check hoses, vacuum chamber, and beaker for cracks before use. Do not use any damaged materials under a vacuum. Always wear chemical splash goggles when performing chemical demonstrations.

Procedure

1. Place the marshmallow figure into the vacuum chamber system. *Note:* Do not place the marshmallow figure near the opening to the pump—it may get sucked into the pump. To guard against this, place a beaker upside down over the opening.
2. Connect the vacuum chamber to the vacuum pump with heavy-walled vacuum tubing.
3. Turn on the vacuum pump to evacuate the chamber.
4. Watch as the marshmallow figure becomes larger and larger.
5. When the chamber is fully evacuated and the figure is as large as it will get, allow air back into the chamber *before* turning off the pump. *Note:* If the pump is shut off before venting to the atmosphere, grease and oil will be pulled out of the pump and into the tubing and vacuum chamber.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. Dispose of materials in the trash according to Flinn Disposal Method #26a.

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Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Constancy, change, and measurement
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure and properties of matter

Tips

- When beginning your discussion of gas laws, slightly inflate a balloon, tie it closed, and then place it into the vacuum chamber. Slightly inflating a latex glove and securely tying off the opening also works well. Evacuate the chamber and have your students explain what happens in terms of the gas laws.
- For best results, use fresh marshmallows.
- During the procedure, some of the air bubbles in the marshmallow figure will "break" and the marshmallow may begin to shrink slightly before air is allowed back into the chamber. This is why the figure ends up smaller than the original when atmospheric pressure is restored.
- Another simple activity is to place a cup with a small amount of shaving cream in the vacuum chamber. Again the air bubbles inside the shaving cream will expand.
- Some teachers have made stick people out of marshmallows and toothpicks and expanded them.

Discussion

When the vacuum pump is turned on and the vacuum chamber is evacuated, the pressure inside the chamber decreases. The lower pressure on the marshmallow bunny causes its volume to increase according to Boyle's Law (*Equation 1*). The expansion is due to the many trapped air bubbles (like small "internal balloons") within the marshmallows that initially are at atmospheric pressure. As the pressure outside these air bubbles (within the chamber) is reduced, the bubbles will expand to many times their original volume in order to equilibrate the pressure on either side of the bubble wall. Thus as the pressure decreases, volume increases in an inverse relationship. This increase in volume makes for a memorable visual event and a great stimulus for the discussion of the elements of Boyle's Law. Students can visualize the loss in pressure and easily see the increase in volume.

$$P_1 \times V_1 = P_2 \times V_2 \qquad \textit{Equation 1}$$

Boyle's Law

Acknowledgments

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Materials for *Easter Bunny Meets the Vacuum Pump* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1597	Pump, Vacuum, Two stage
AP4506	Vacuum Chamber with Plate
AP8789	Tubing, Vacuum, 10 feet

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.