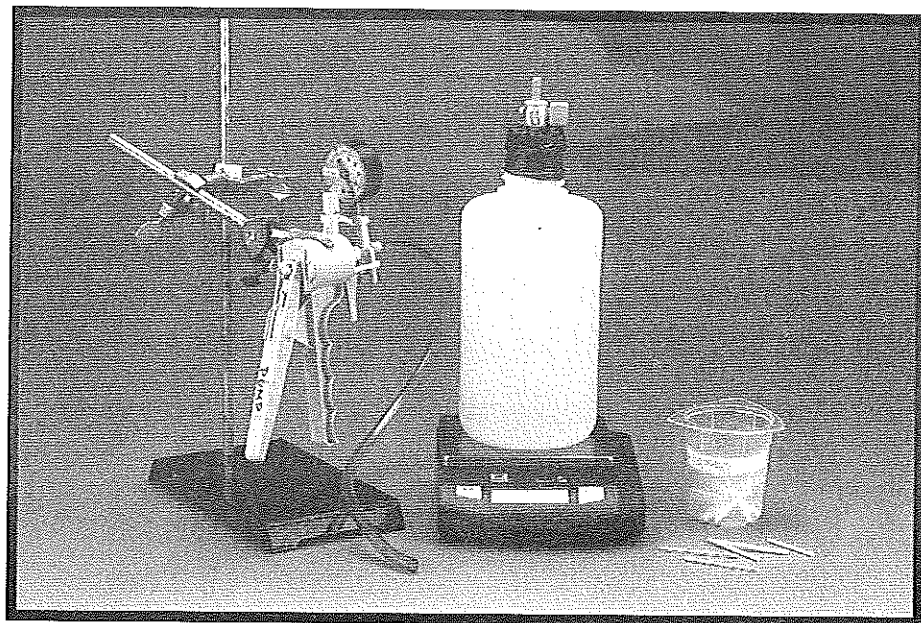


EXPERIMENT

As Light as Air

Visitors measure the mass of air by weighing a bottle both before and after removing air from the bottle.



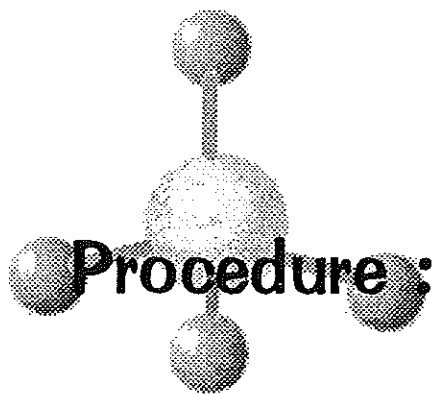
OBJECTIVES:

Visitors learn that air has mass.

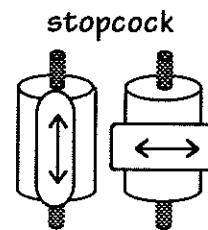
SCIENCE TOPICS	PROCESS SKILLS	VOCABULARY
Properties of Matter	Observing	Density
Properties of Gases	Measuring	Gas
Density	Inferring	Liquid
		Mass
		Molecule
		Solid



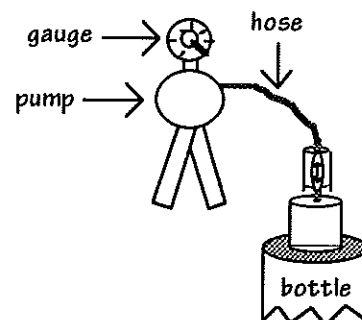
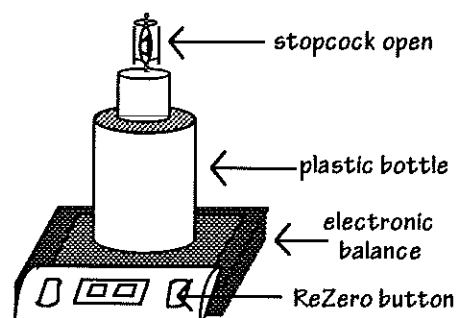
As Light as Air



1. Always wear safety goggles.
2. Remove the hose from the stopcock. Make sure that the stopcock is in the open position. Place the plastic bottle on the metal pan of the electronic balance.
3. Press the "ReZero" button. The balance should now read 0.0 g.
4. Remove the bottle from the balance. Connect the hand-pump hose to the stopcock on the plastic bottle.
5. Squeeze the pump handle as many times as is necessary (about 20 times) to move the needle on the gauge to the red line or higher. (You are pumping air out of the bottle.) Close the stopcock and remove the hose.
6. Place the bottle back on the balance.
Does the bottle weigh more or less than it did before? Why?
7. Place straws one at a time next to the bottle on the balance until the balance reads zero again.



open closed

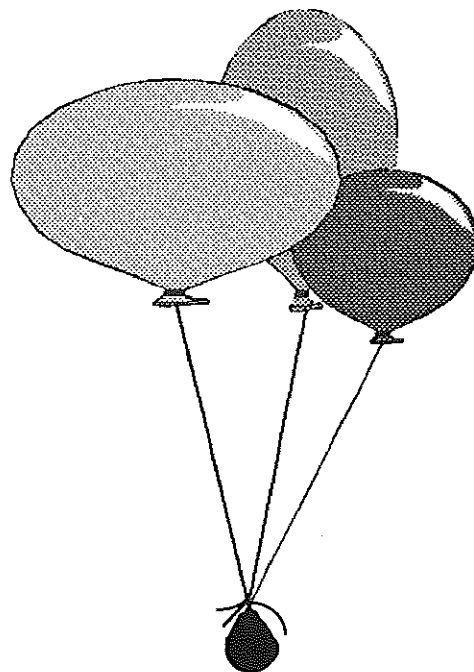


How many straws did you use?

Hold the straws in your hand; how heavy do they feel?

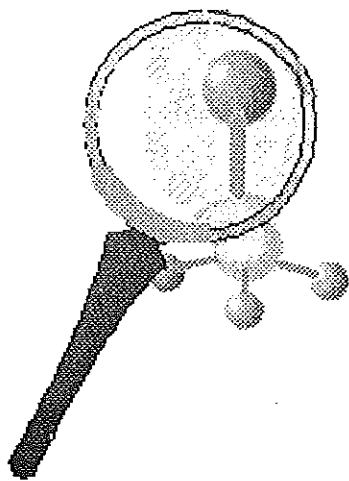
8. Open the stopcock on the plastic bottle; what do you hear?
9. Return the straws to the beaker and remove the bottle from the balance.

How much does air weigh?



A Closer Look:

At first, the bottle you weighed was filled with air. It weighed less after you pumped out the air. When you reopened the stopcock, you heard the air rushing back in to fill the bottle. The straws you used to re-zero the balance weigh the same as the air that was in the bottle. (about 0.5 gram or 1/1000 of a pound).



Air consists mainly of molecules of the gases nitrogen (N_2), oxygen (O_2), and carbon dioxide (CO_2). Even though you usually can't see or feel these molecules, the air around you is full of them. Air is much less dense than liquids or solids, because air molecules are much farther apart from each other. Air still has weight. When you feel a gust of wind or blow out a candle, you experience the effects of air molecules.

MATERIALS**(with amounts to have on hand)**

- One electronic balance with a large balance pan, 0.1-g precision, and at least 300-g capacity (Ohaus, Scout SC6010 balance works well)
- 20 plastic coffee-stirring straws
- One 250-ml plastic beaker
- One 2-L heavy-duty plastic bottle
- One 1-hole rubber stopper to fit the plastic bottle
- One 2-way valve with two male ends to fit the plastic tubing and 1-hole rubber stopper
- 1 ft of plastic tubing (about 7 mm in diameter)
- One Nalgene 36-cc hand vacuum pump with a gauge (keep one extra on hand)
- One small ring stand
- One ring stand clamp
- Vacuum grease

Setup/Takedown Procedures**ORIGINAL SETUP**

- ☐ Cut the coffee-stirring straws in half and flatten them so that they do not roll.
- ☐ Label the plastic beaker "Straws."
- ☐ Dismantle the valve and apply vacuum grease to the turning cylinder. Reassemble the valve.
- ☐ Label the "Open" and "Closed" positions on the valve.
- ☐ Insert one end of the valve securely into the rubber stopper. Insert the stopper assembly into the neck of the bottle. Secure the stopper to the bottle with electrician's tape. Apply vacuum grease to the free end of the valve.
- ☐ Label the vacuum gauge "Gauge."
- ☐ Use a red permanent marker to draw a line on the gauge at 5 in. of Hg (mercury).
- ☐ Label the pump handle "Pump."
- ☐ Attach one end of the rubber tubing to the pump outlet.
- ☐ Clamp the pump securely to the ring stand in a position to allow easy pumping.

WEEKLY SETUP

- ☐ Get the balance from general storage.
- ☐ Cover the "Mode/Off" button on the balance with opaque tape.
- ☐ Place the straws in the labeled beaker.

DAILY SETUP

- ☐ Set out the public copy in a Plexiglas holder.
- ☐ Set out the labeled plastic beaker with straws inside.
- ☐ Set out and plug in the balance.
- ☐ Make sure the balance is on and set for grams. (To use the balance, press the "Mode/Off" button until "g." appears. Press and hold the "Mode/Off" button to turn the balance off.)
- ☐ Make sure the "Mode/Off" button (on the balance) is covered with opaque tape.
- ☐ Set out the bottle with the stopper assembly.
- ☐ Set out the ring stand with the clamp and pump.
- ☐ Check the pump and bottle by pumping out the bottle, following the directions in the public copy. If it doesn't work, add a little vacuum grease to the end of the valve or the valve cylinder, retape the stopper to the bottle, or try the backup pump.

DAILY TAKEDOWN

- ☐ Return all equipment to the tub.
- ☐ Turn off the balance and make sure it is clean and dry.

WEEKLY TAKEDOWN

- ☐ Return the balance to storage.

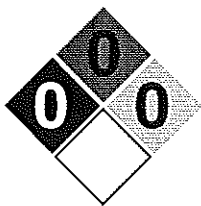
**RUNNING SUGGESTIONS**

- ◇ Visitors may have trouble attaching and removing the hose to and from the valve. Vacuum grease on the end of the valve should help.
- ◇ Visitors may have some trouble pumping. Suggest using two hands and letting the pump handle release fully between pumps. (Note: The gauge does not register until after about five pumps.)
- ◇ The weight difference before and after the vacuum pump is applied should be about 0.8 g. If the visitor gets a difference of less than 0.5 g, have him or her repeat the experiment.

**EXTENSIONS**

Try this with larger bottles if the balance is big enough.

If you try it with lighter bottles, they will collapse from the surrounding air pressure.

SAFETY & DISPOSAL

No special precautions are needed; follow standard lab safety procedures.