



grades 4–12 ✓ **Hands-On Activity**
grades 6–8 ✓ **Demonstration**
grades 6–8 ✓ **Learning Center**

Showing That Air Has Mass

...Students use a soccer ball to discover that air meets the criteria for being matter: it has mass and takes up space.

✓ **Time Required**

Setup	none
Performance	10 minutes
Cleanup	none

✓ **Key Science Topics**

- criteria for matter
- gases
- mass

✓ **Student Background**

Students should understand that the two criteria for matter are having mass and occupying volume. Do at least one of the activities showing that air takes up space (“Balloon in a Bottle,” “Burping Bottle,” and “Tissue in a Cup”) before doing this activity.

✓ **National Science Education Standards**

Science as Inquiry Standards:

- Abilities Necessary to Do Scientific Inquiry

Students think critically and logically about their observations of the soccer ball and form a logical argument about the cause-and-effect relationship in the investigation.

Physical Science Standards:

- Properties and Changes of Properties in Matter

The characteristic properties of all matter are having mass and taking up space.

✓ **Additional Process Skills**

- observing Students see how pumping air into the ball affects its mass.
- measuring Students determine the mass of the ball with various amounts of air in it.
- inferring Students use the observed masses to conclude that air satisfies one of the criteria of matter.



Air trapped inside a soccer ball



MATERIALS

For the Procedure

Per class

- soccer ball or other semi-rigid, constant volume, yet inflatable ball
- air pump
- pump needle
- base from a plastic 2-L soft-drink bottle or other object to hold the ball in place on the balance pan
- balance (with capacity to measure the mass of the soccer ball, about 320 g, to at least the nearest 0.1 g)



A double-pan balance can be used to show changes in mass without taking quantitative measurements.



SAFETY AND DISPOSAL

Do not over-inflate (and hence rupture) the ball. No special disposal procedures are required.



GETTING READY

If the ball is inflated to its normal playing pressure, insert the needle to equalize the inside and outside pressures, and then remove the needle. So that the ball will occupy its normal volume, do not squeeze the ball when removing the needle.



INTRODUCING THE ACTIVITY

Discuss and compare some of the properties characteristic of materials in the solid, liquid, and gaseous states. Ask if these materials are all forms of matter. Ask, "What is matter?" *Anything that has mass and occupies space is matter.*

Ask the students if they think that air is matter. What must they show in order to prove that air is matter? *That air has mass and occupies space.* Ask students how they would demonstrate that air takes up space. (The "Balloon in a Bottle," "Burping Bottle," and "Tissue in a Cup" activities in this book demonstrate that air occupies space. If students have done one or more of these activities, they should have plenty of suggestions.) Ask students how they would demonstrate that air has mass. Give students a chance to suggest ideas. Discuss the difficulty of measuring the mass of air. Then tell students that you have a way to demonstrate that air has mass.



PROCEDURE

1. Show students the soccer ball. Ask them what is inside the ball. *Air.* Place the soccer ball on the soft-drink bottle base in order to keep it from rolling off the balance. Ask a student volunteer to determine and record the combined mass of the ball and base. Ask, "What items does this mass measurement include?" *The ball, the base, and the air inside the ball.*
2. Remove the ball from the balance and bottle base and inflate the ball to normal playing pressure. Be careful not to overinflate (and hence rupture) the ball. Ask, "What have I just put inside the ball?" *More air.*
3. Ask students to predict whether the mass measurement of the ball will be different. Have them explain their predictions. Again, have a student volunteer measure the combined mass of the ball and the soft-drink bottle base.
4. As a class, compare the masses from Steps 1 and 3.
5. Ask students what conclusions they can make based on the data. If necessary, lead students to infer that air has mass, a necessary criterion for matter.
6. Remind students that they learned that air occupies volume in the activities "Balloon in a Bottle," "Burping Bottle," and "Tissue in a Cup." Ask, "What can you now conclude about air based on the results of the two activities?" *Since air occupies volume and has mass, air is matter.*



VARIATION

Set up the activity in a learning center and have students conduct the investigation using the Instruction and Observation Sheet (provided).



EXPLANATION



The following explanation is intended for the teacher's information. Modify the explanation for students as required.

Matter is anything that has mass and occupies volume. Both of these criteria are relatively easy to observe for liquid and solid samples but much more difficult for gaseous samples. This activity demonstrates that air (in the gas state) has mass, one of the two criteria of matter. (The "Balloon in a Bottle," "Burping Bottle," and "Tissue in a Cup" activities in this book demonstrate that air occupies space.)

This activity uses a ball with a semi-rigid case of leather or vinyl as a container for air. If the walls are not pushed in prior to adding extra air, such a container maintains a constant volume as more air is added. (Placing

Showing That Air Has Mass

Instruction and Observation Sheet

1. Observe the soccer ball. What is inside it? _____

Place the soccer ball on the soft-drink bottle base in order to keep it from rolling off the balance. Determine and record the combined mass of the ball and base. _____

What items does this mass measurement include? _____

2. Remove the ball from the balance and bottle base and inflate the ball to normal playing pressure. Be careful not to overinflate (and hence rupture) the ball. What did you just put inside the ball?

3. Predict whether the mass of the ball will be different. Explain your prediction.

Again, measure the combined mass of the ball and the soft-drink bottle base and record the mass.

4. Compare the masses from Steps 1 and 3. Was your prediction right? What conclusions can you make based on your data?

5. What are the two criteria for something to be classified as matter?

6. Remember that you have already learned that air takes up space in another activity. What can you now conclude about air based on the results of this activity and the fact that air takes up space?
