

# The Ball That Got Heavier: Is Air Something?

**Learning target:** I can describe a puzzling observation about air and mass, and write a first explanation that I can test later.

Phenomenon exploration

About 25 min

Individual

MS-PS1-1 · supports

discussion

writing

## Standards connections

**MS-PS1-1 (supports):** Before students can model molecules made of atoms, they need to accept that invisible gases are matter made of particles with mass. This phenomenon builds that foundation; it does not yet produce evidence toward the molecular models the PE asks for.

**Purpose:** activate · **Time:** about 25 minutes · **Format:** individual

## Answers with reasoning

### The demonstration

Ms. Ortega puts a flat basketball on a digital balance that reads to one tenth of a gram. The ball is limp but still holds its round shape because the leather is stiff. The balance reads **598.4 g**. She lifts the ball off, pumps forty strokes of air into it with a hand pump, wipes the needle dry, and puts the ball back on the same balance. Now it reads **603.1 g**. She pumps forty more strokes. The reading climbs again, to **607.7 g**. The ball looks exactly the same size as it did when it was flat; a tape measure around the middle gives the same 75 cm every time. Nothing was added that anyone could see.

### Same ball, same size, different reading

| Flat ball (0 pump strokes)      | Pumped ball (40 pump strokes)   |
|---------------------------------|---------------------------------|
| Balance reads 598.4 g           | Balance reads 603.1 g           |
| Distance around the ball: 75 cm | Distance around the ball: 75 cm |
| Feels soft when squeezed        | Feels hard when squeezed        |
| Looks 'empty' inside            | Still looks 'empty' inside      |

Teaching data: the masses are invented to be realistic for a 7.1 liter ball, not measured in a real lab.

## Part A: Notice and wonder

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1. List three things you **notice** in the description or the figure. Use only facts that were observed or measured, not explanations. Include at least one number.

**Answer:** Any three observations, for example: the flat ball read 598.4 g; after 40 strokes it read 603.1 g; after 80 strokes it read 607.7 g; the distance around the ball stayed 75 cm; the pumped ball felt hard; nothing visible was added; the inside still looked empty.

**Why:** The point of a notice list is to separate observation from explanation. A statement such as 'air has mass' is an explanation, not an observation, and should be gently redirected.

*Also acceptable: Observations about the pump, the wiping of the needle, or the stiff leather also count.*

- Three statements that are observations, not explanations
- At least one includes a measured number
- Statements are taken from the description or figure

2. Write two questions you **wonder** about. At least one should be a question that could be answered by doing another measurement.

**Answer:** Sample wonderings: Does every pump stroke add the same amount of mass? Would a bigger ball gain more? Would the ball get lighter again if the air were let out? Is it the air that has mass or something else in the pump? Would helium make the reading go up by less?

**Why:** At least one question should be testable with another measurement (for example, measure after 10, 20 and 30 strokes). Questions like 'Why does air exist?' are fine as curiosity but do not meet the testable requirement.

*Also acceptable: A question about the balance's accuracy is acceptable and testable (weigh a known mass).*

- Two genuine questions
- At least one is answerable with a measurement

3. How much mass did the first forty pump strokes add? How much did the second forty strokes add? Show your subtraction for both.

**Answer:** First 40 strokes:  $603.1\text{ g} - 598.4\text{ g} = 4.7\text{ g}$ . Second 40 strokes:  $607.7\text{ g} - 603.1\text{ g} = 4.6\text{ g}$ .

**Why:** Students should notice the two gains are almost equal, which hints that each stroke adds about the same amount of air (about 0.12 g per stroke). The small difference (0.1 g) is within what a tenth-of-a-gram balance can resolve.

*Also acceptable: Accept 4.7 g and 4.6 g, or a total of 9.3 g for all 80 strokes if the student also shows the two separate steps.*

## Part B: What do you already think?

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4. Which statement is closest to what you believe **right now**? Circle one. (There is no penalty for a wrong choice; this is a snapshot of your thinking.)

**Answer:** B. Air is matter made of particles that are too small to see, and each particle has mass.

**Why:** This is a belief snapshot, so any honest choice earns credit. B is the scientifically accurate option. Record the class tally; many students choose A or C at first, which is useful information for the misconception work in W7.

*Also acceptable: Full credit for any option as long as one is circled.*

5. Pick a different option from the one you circled in q4. What observation from the demonstration makes that option hard to believe?

**Answer:** Examples: Option A is hard to believe because the pump only draws in air from the room, and the gain repeated almost exactly on the second forty strokes. Option C is hard to believe because the balance read the same 75 cm ball at a steady value each time and only changed after pumping. Option D is hard to believe because the needle was wiped dry and the leather did not look or feel wet.

**Why:** The student must connect a specific observation to the option they reject. Rejecting an option 'because it sounds wrong' does not earn full credit.

*Also acceptable: A student who circled B in q4 may reject any of A, C or D.*

- Names a different option than q4
- Cites a specific observation from the demonstration
- Explains why that observation conflicts with the option

## Part C: Your first explanation

6. Explain why the balance reading went up even though the ball looked the same and nothing visible was added. Your explanation must (a) say what the pump put into the ball, (b) say why that thing cannot be seen, and (c) say why the ball got harder to squeeze.

**Answer:** The pump pushed air into the ball. Air is a gas made of particles (mostly nitrogen and oxygen particles) that are far too small to see, and each particle has a tiny mass; billions of billions of them add up to a few grams. The ball got harder because many more particles were crowded into the same 7.1 liter space, so they push outward on the inside of the leather more strongly.

**Why:** This is an initial explanation, so a partially correct particle idea earns credit. Watch for the key move: the student must say that something with mass was added even though it is invisible. The pressure idea (more particles in the same space push harder) is a bonus at this stage and will be developed in later lessons.

*Also acceptable: A student who writes 'air is made of atoms' or 'molecules' is correct; both terms are acceptable here. A student who says the ball got harder because the air inside is 'pushing' earns the third criterion.*

- States that the pump added air (a gas)
- Explains invisibility by particle size (or at least says the stuff is too small to see)
- Connects the harder ball to more air packed into the same space

7. Predict: if Ms. Ortega opened the valve and let all the air hiss out, what would the balance read? Explain your prediction in one sentence.

**Answer:** About 598.4 g, the flat reading, because the air that was added would leave and the ball would be back to its original contents.

**Why:** The prediction tests whether the student sees the mass gain as reversible and caused by the air. A prediction slightly above 598.4 g (because some air stays inside) is also well reasoned.

*Also acceptable: Accept 'a little more than 598.4 g because not all the air escapes' with that explanation.*

8. A switched-off neon sign looks like an empty glass tube, yet it glows red when electricity flows through it. How is the neon tube like the basketball?

**Answer:** Both look empty but are not. The neon tube holds a huge number of neon atoms that are too small to see, just as the ball holds air particles that are too small to see. In both cases the invisible stuff is real matter; it shows up as mass on the balance or as a red glow when electricity passes through.

**Why:** This question previews the lesson's main idea: 'clear' is not the same as 'empty.' The connection should be about invisible particles that are still matter.

*Also acceptable: A student who says 'both contain a gas you cannot see' meets the criteria.*

- Says the tube is not actually empty
- Links the invisible contents to the invisible air in the ball

## Teacher notes

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The basketball is a better phenomenon than a stretchy balloon because its size does not change, so the upward push of the surrounding air is the same before and after pumping and the whole mass gain is real added air (about 0.12 g per stroke in this teaching dataset). If you demonstrate it live, use a balance that reads to 0.1 g and a ball that holds its shape when flat. Collect q4 tallies to plan the misconception work in W7. Keep q6 answers; students revise them at the end of the lesson.

### Scaffold offered to students: Sentence starters for Part C

If you are stuck on q6, begin with: 'The pump pushed \_\_\_\_\_ into the ball. We cannot see it because \_\_\_\_\_. The ball got harder because more \_\_\_\_\_ were packed into the same space, so they \_\_\_\_\_ against the inside of the ball.' Replace the blanks with your own ideas; you may cross out any starter that does not fit your thinking.

### Extension: Design a check

The flat ball and the pumped ball have the same size, so the air around them pushes up on both equally. Now imagine the same experiment with a stretchy party balloon instead of a rigid ball. The inflated balloon is much bigger than the empty one. Write a short paragraph predicting whether the balance would show the full mass of the air that was blown in, more than that, or less than that, and why a bigger object in air might read differently. (Hint: think about why a helium balloon rises.)