

The Jar That Sorts Things: Five Liquids, Four Objects

Learning target: I can record careful observations of liquids and objects settling into layers, and write a first explanation of what decides where each one stops.

Phenomenon exploration

About 25 min

Individual

MS-PS1-2 · practice

MS-PS1-1 · supports

discussion

writing

Standards connections

MS-PS1-2 (practice): Students begin noticing that a substance has properties, such as density, that do not depend on the size of the sample. That is the kind of property data the PE asks them to analyze; this sheet only starts the habit of observing and questioning.

MS-PS1-1 (supports): Background link: the liquids and objects in the jar are macroscopic samples of molecules and extended structures that students modeled in the previous chapters. Students connect the visible layers to the invisible particles they are made of.

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

Answers with reasoning

The demonstration

Mr. Castillo sets a tall glass jar on the front table. One at a time he pours in five liquids: honey, green dish soap, water tinted red, vegetable oil, and rubbing alcohol tinted blue. He pours each one slowly down the inside of the glass. Then he drops in four small objects: a cork, a plastic bottle cap, a grape, and a steel bolt. The class watches for ten minutes. The liquids settle into five bands. Each object stops at a different level and stays there.

Five bands and four resting places

Blue rubbing alcohol: the cork floats on top of this band	top
Vegetable oil: the bottle cap rests on top of this band	
Red water	
Green dish soap	
Honey: the grape rests on top of this band; the steel bolt sits on the jar's bottom	bottom

The jar after ten minutes. Band thickness is not to scale. The objects are drawn where they came to rest.

Before class, Mr. Castillo had tried the demonstration twice with the same five liquids but poured in a different order each time. His notes are below. The order he poured changed. The order of the bands after ten minutes did not.

Mr. Castillo's practice runs (pouring order)

Run	Poured first	Poured second	Poured third	Poured fourth	Poured fifth	Band order after ten minutes, top to bottom
Run 1	honey	dish soap	water	oil	alcohol	alcohol, oil, water, soap, honey
Run 2	alcohol	honey	oil	dish soap	water	alcohol, oil, water, soap, honey

The four objects (measured on the classroom balance)

Object	Mass (g)	Where it stopped
Cork	2.0	top of the alcohol band
Plastic bottle cap	1.5	top of the oil band, under the alcohol
Grape	5.0	top of the honey band, under the soap
Steel bolt	12.0	bottom of the jar

Part A: Notice and wonder

1. Write at least four things you **notice** about the jar and the tables. Each one must be something another student could check by looking, not an explanation. Include at least one noticing about the liquids and one about the objects.

Answer: Any four checkable observations, for example: the five liquids formed five separate bands; honey is on the bottom and alcohol on top; the band order was the same in both practice runs even though the pouring order was different; each object stopped at a different level; the bolt went all the way to the bottom; the cork is the only object above every liquid; the cap has less mass than the cork but sits lower; the grape passed through four liquids and stopped on the honey.

Why: Noticings must be observations, not causes. A statement such as 'the bolt sank because it is heavy' is an explanation and belongs in Part C.

Also acceptable: Observations about color, pouring order or the ten-minute wait are acceptable.

- At least four observations
- Each one could be checked against the figure or tables
- At least one about liquids and one about objects

2. Write at least three things you **wonder**. Start each with 'Why', 'What if' or 'How'. At least one should be about Run 2 in the pouring table.

Answer: Examples: Why did the liquids end up in the same order in Run 2 when alcohol was poured first? What if the jar were shaken, would the bands come back? How does the water know to stop above the soap? Why does the grape sink through water but not through honey? What if we used a bigger bolt? Would a bigger cork still float on top?

Why: Wonderings should be answerable by investigation. The Run 2 question gets at the idea that the final order depends on the liquids themselves, not on the order of pouring.

Also acceptable: Accept questions about safety or about what the liquids are made of.

- At least three wonderings with the required starters
- At least one is about Run 2

3. Look at the object table. List the four objects in order from least mass to most mass. Then list them in order from highest resting place to lowest. Are the two lists the same?

Answer: By mass, least to most: cap (1.5 g), cork (2.0 g), grape (5.0 g), bolt (12.0 g). By resting place, highest to lowest: cork, cap, grape, bolt. The two lists are not the same: the cork and the cap swap places.

Why: This item sets up q5. The swap is the evidence that mass by itself does not rank the objects.

Also acceptable: Accept either list written in the opposite direction as long as the student says whether the orders match.

Part B: What do you already think?

4. Which statement is the best reason the steel bolt ended up on the bottom?

Answer: B. Steel is denser than every one of the five liquids, so no liquid can hold it up.

Why: Option A confuses mass with density (a bigger cork would have more mass than the bolt and still float). Option C is false; the objects were dropped after all liquids were in and order of dropping does not matter. Option D is false; steel floats on mercury, and aluminum foil can float on water when surface tension helps. Students may not know these counterexamples yet; accept B with any reasoning that points to the material rather than the object's mass.

Also acceptable: A student who chooses A and writes 'because it has the most mass for its size' has the right idea and should be moved toward B in discussion.

5. The bottle cap (1.5 g) has less mass than the cork (2.0 g), yet the cap stopped **lower** than the cork. What does this tell you about using mass alone to predict where an object will stop?

Answer: Mass alone cannot predict the resting place. The cap has less mass than the cork but stopped lower, so something else about the object, not just how much matter it has, decides the level. (Full explanation, for later: the cap is denser than the cork, and density, mass per unit of volume, is what matters.)

Why: Students should state the limitation clearly. Naming density is a bonus, not a requirement, at this stage.

Also acceptable: Accept 'it depends on what the object is made of' or 'it depends on size and mass together.'

- States that mass alone does not predict the level
- Uses the cap-cork comparison as evidence

Part C: Your first explanation

6. Write your first explanation of **two** things: (a) why the five liquids settled into the same order in both practice runs no matter how they were poured, and (b) what decides the level at which each object stops. Use the words *substance* and *property* at least once each.

Answer: Sample strong response: (a) Each liquid is a different substance, and each substance has its own property that decides whether it ends up above or below another liquid; the property belongs to the substance, so pouring order cannot change it, and the liquids rearrange until the order matches their properties. (b) Each object stops at the first band that can hold it up; an object sinks through liquids that are 'lighter for their size' than the object and floats on the first liquid that is 'heavier for its size.' The property that matters is how much mass the substance packs into a given volume, not the total mass.

Why: This is a first explanation. Full credit requires an explanation for both parts, use of the two required words, and an idea that a property of the substance (not pouring order or total mass) sets the order. The word density is welcome but not required.

Also acceptable: A student who proposes 'thickness' (viscosity) as the deciding property has a testable but incorrect idea; honey is both thick and dense, so the jar cannot tell the two apart. Note it for the class discussion rather than marking it wrong.

- Explains the repeatable band order
- Explains object resting places
- Uses substance and property
- Explanation is testable (a test could prove it wrong)

7. Name one measurement you could make on each liquid, using only a balance and a measuring cup, that might predict its band position. Describe exactly what you would measure and compare.

Answer: Measure the mass of the same volume of each liquid, for example 100 mL of each in the same cup, subtracting the cup's mass. Compare the masses. The prediction: the liquid with the most mass per 100 mL should be lowest in the jar and the one with the least should be on top.

Why: The essential idea is comparing mass at equal volume (or computing mass divided by volume). Comparing masses of different amounts would not work.

Also acceptable: Accept 'weigh equal cups of each' or 'find grams per milliliter.'

- Uses equal volumes (or divides mass by volume)
- Says how the result would be compared with band position

8. Mr. Castillo now drops in a small piece of pencil eraser (rubber). Predict which band it will stop in or on, and give the reasoning behind your prediction. You do not have enough information to be sure; say what would make you more sure.

Answer: A reasoned prediction with a stated uncertainty, for example: 'An eraser sinks in a sink full of water, so it will go below the water band; I predict it stops on the soap or the honey. I would be more sure if I knew the mass of a measured volume of eraser and of each liquid.' (For the teacher: a typical rubber eraser has a density of about 1.1 to 1.3 g/cm³, so it would sink through the soap, about 1.04 g/cm³, and rest on the honey, about 1.4 g/cm³, next to the grape.)

Why: Credit is for a prediction tied to an observation or reasoning and for naming the missing information, not for the exact band.

Also acceptable: Any band is acceptable if the reasoning and the missing information are stated.

- Makes a specific prediction
- Gives a reason
- Names what information would make the prediction more certain

Teacher notes

This is a described demonstration; the layers are a classic density column and the resting places follow from approximate densities (g/cm³): rubbing alcohol about 0.82 (91% isopropyl) to 0.88 (70%), vegetable oil about 0.92, water 1.00, dish soap about 1.03 to 1.06, honey about 1.4; cork about 0.24, polypropylene bottle cap about 0.90, grape about 1.1, steel about 7.9. If you reproduce it, the cap's margin above the oil is small (0.90 versus 0.92), so use a known polypropylene cap and expect it to sit just at the oil surface. Dish soap mixes with water over hours, so observe within the period. Pour slowly over the back of a spoon. The object masses in the table are stated values for this scenario, chosen so that the cap-cork swap in q3 appears. Do not give away density here; the goal is for students to leave with a testable idea ('mass for the same volume') that W5 and Lab 1 will measure. Common first explanations to surface in discussion: 'heavier things sink' (confronted by q5), 'thicker liquids sink' (viscosity, not distinguishable with this jar), and 'the first thing poured stays on the bottom' (confronted by Run 2).

Scaffold offered to students: Noticing sentence starters

If you are stuck on Part A, use these frames and fill in the blanks from the figure and the tables: 'The ___ band is above the ___ band.' 'The ___ stopped on top of the ___.' 'In Run 2, ___ was poured first, but it ended up ___.' 'The object with the most mass is ___, and it stopped ___.' Each completed frame is one noticing.

Extension: Design a sixth band

Suppose Mr. Castillo wants to add a sixth liquid that would settle **between** the water and the dish soap. Describe what you would need to know about the new liquid before choosing it, how you would measure that with a balance and a graduated cylinder, and how you would test your prediction without taking the jar apart. Then explain why pouring the new liquid in last would still put it in the middle.