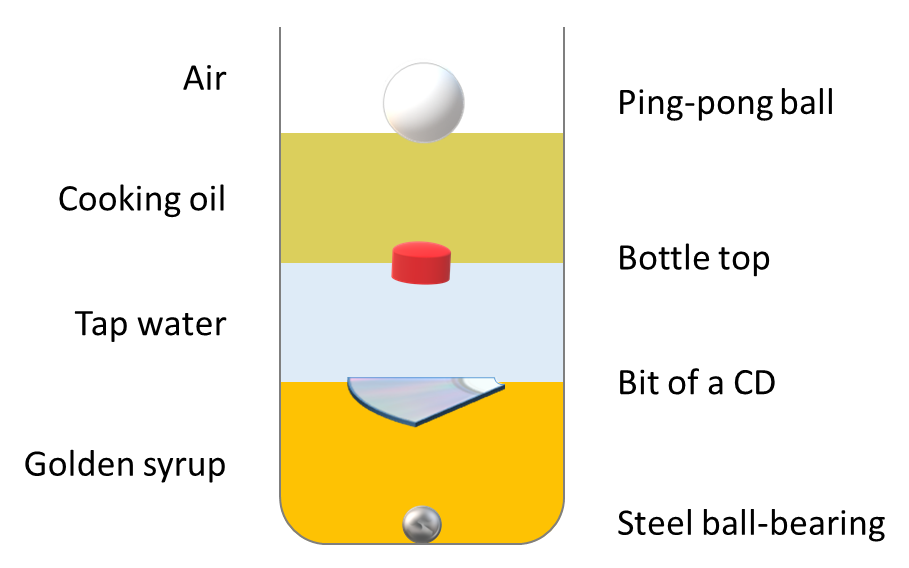
**Density column**

A density column contains different liquids.

The liquids are in layers.

Different objects float on the different layers.



*For each statement, tick (✓)* ***one*** *column to show what you think.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | The bottle top floats on golden syrup. |  |  |  |  |
| **B** | The CD floats on cooking oil. |  |  |  |  |
| **C** | Cooking oil has a higher density than water. |  |  |  |  |
| **D** | The CD has a higher density than the bottle top. |  |  |  |  |

*Physics > Big idea: PMA Matter > Topic PMA2: Floating and sinking > Key concept PMA2.1: Floating, sinking and density*

|  |
| --- |
| **Diagnostic question** |
| **Density column** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | An object that is surrounded by a fluid (liquid and/or gas) floats if its overall density is less than the density of the fluid. |
| Observable learning outcome: | Explain how the density of a liquid (or gas) determines how well objects float in it. |
| Question type: | Confidence grid |
| Key words: | Floating, sinking, density |

|  |  |
| --- | --- |
| **B** | **BRIDGING**  This diagnostic question probes understanding of ideas that are usually taught at age 14-16, to build a bridge to later stages of learning. |

**What does the research say?**

Paik et al. (2017) describe a learning progression for buoyancy that begins with the basic concepts of weight and volume, before starting to develop the scientific concepts of density and buoyancy. In their progression, the density of an object is introduced as the object being *heavy (or light) for its size*. This working definition of density allows students to develop understanding of how volume and weight combine to give an object its buoyancy, and provides descriptive tools that help explain why boat-shaped objects (that are filled with air) are more buoyant than other more compact shapes. This idea is also linked to the understanding that buoyancy increases as the volume of liquid (or gas) displaced increases. Buoyancy is defined as the resultant upward force of the liquid (or gas) around an object, on the object.

It is appropriate to teach students how to calculate buoyancy only after they have developed a good qualitative understanding how it works (Gao et al., 2018). Students can use a displacement can to measure the weight of water displaced by an object and compare this to the weight of the object. Buoyancy is equal to the weight of the water (or other fluid) displaced. Objects that float displace their own weight of water. If the weight an object is greater than the weight of the water the object displaces, then the object will sink. In other words: if an object is less dense than the liquid (or gas) that it is placed in it will float; if it is denser it will sink.

**Ways to use this question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Equipment**

For the class (optional demonstration):

* Large, tall glass beaker (about 1 litre)
* Golden syrup (density = 1.43 g/cm3)
* water (1.00 g/cm3)
* cooking oil (0.92 g/cm3)
* Ping-pong ball (0.08 g/cm3)
* plastic bottle top (0.95 g/cm3)
* piece of a CD – polycarbonate (1.2 g/cm3)
* steel ball-bearing (7.9 g/cm3)

**Expected answers**

Statements A and D are correct.

Statements B and C are wrong.

**How to respond - what next?**

In the density column the liquids arrange themselves in layers, with the least dense on top. (If demonstrating the column then give the liquids at least 15 minutes to settle out into clear layers.) When the solid objects are added, each one falls through liquids that have a lower density than the object, and float on those that have a higher density.

1. Most students are likely to get this correct, the top floats on the syrup because it has a lower density than the syrup. Some students choosing this answer, however, are likely to choose it because the syrup is ‘thicker’ (more viscous) than the water, and because the top is floating on the water. This misunderstanding may lead to a wrong prediction for statements B and C.
2. The CD sinks through the cooking oil, because it has a higher density than the oil. Students who think the CD floats are likely to have equated density with ‘thickness’ (viscosity) of the liquid. They may think that the CD can float on the oil because the oil is thicker than water, and is more resistant to the movement of the CD through it.
3. Cooking oil floats on water as it is less dense than water. Some students may suggest it floats, because it does not mix with the water. They may think it has a higher density than water because, in comparison, it is thicker and harder for an object to move through.
4. If students are thinking about density as a property of the object that is floating, they may have uncertainties about which plastic is the more dense. The bottle top floats on water and the CD sinks in water because of their relative densities. A few students may suggest the bottle top floats more easily, because it has a ‘boat-shape’.

If students have misunderstandings about how the density of a liquid (or gas) determines how well objects float in it, it can help to demonstrate the density column to the class. In order to focus discussion on the density of different materials, similar sized blocks from a density kit could be used. A wooden block floats on water, polyethylene on water, and Perspex on golden syrup. A steel block sinks in syrup.

The density of liquids can be compared by measuring the mass of equal volumes of each using a balance.

The following BEST ‘response activity’ could be used in follow-up to this diagnostic question:

* Response activity: Grape expectations

**Acknowledgments**

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Images: Peter Fairhurst (UYSEG).

**References**

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Paik, S.-H., et al. (2017). Developing a Four-level Learning Progression and Assessment for the Concept of Buoyancy. *Eurasia journal of mathematics, science and technology education,* 13(8)**,** 4965-4986.