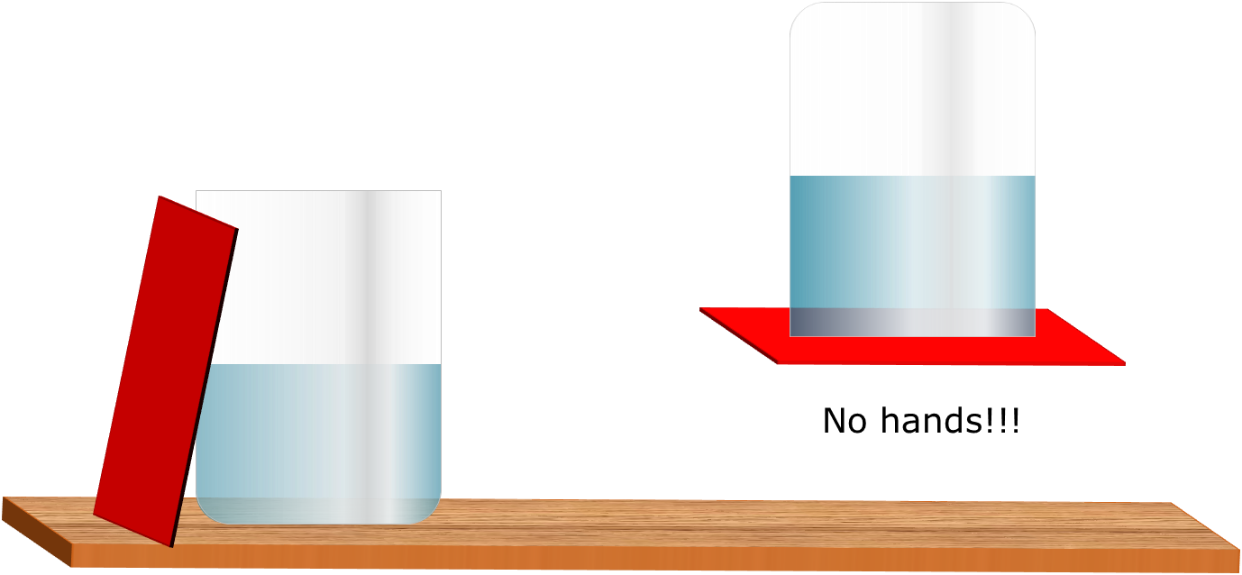
**Magic glass**

A piece of card is placed on top of a glass of water.

Holding the card in place, the glass is turned over.

With no hands, the water stays in the glass!



Why do you think the water stays in the glass?

*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** | Air particles keep bashing into the bottom of the card. |  |  |  |  |
| **B** | There is a lot of pressure from the air on the bottom of the card. |  |  |  |  |
| **C** | The air gap sucks the water back into the glass. |  |  |  |  |

*Physics > Big idea PMA: Matter > Topic PMA2: Floating and sinking > Key concept PMA2.2: Pressure in fluids*

|  |
| --- |
| **Diagnostic question** |
| **Magic glass** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Pressure increases with depth in a fluid, so the force exerted by a fluid is larger on the lower surface of an immersed object than on the upper surface. This results in an upward force on the object. |
| Observable learning outcome: | Explain phenomena that are caused by differences in fluid pressure, on either side of a boundary. |
| Question type: | Confidence grid |
| Key words: | Particles, pressure |

**What does the research say?**

Both Séré, in her study (n=600) of what 11- to 13-year-olds thought about gases ( Séré, 1986), and Besson, in his study (n=944) of upper secondary and university students’ conceptions and reasoning about fluids (Besson, 2004), argue that there is a need for students to systematically reason how the motion of particles cause pressure effects, as a preliminary to the study of pressure, in order to avoid several common misunderstandings.

For students to develop a robust understanding of pressure in fluids, Psillos (1999) suggests that they first observe and describe phenomena caused by fluid pressure, before using ideas about the movement of particles to explain the cause of each one.

Students generally understand increases in pressure, such as when a tyre is inflated, and make links between the amount of a gas squashed into a container and its pressure ( Séré, 1985; Besson, 2004). Some however, consider that there is a *normal amount* of air that if exceeded, causes pressure; and if it is not exceeded, there is *no* pressure ( Séré, 1985). Students find explanations involving reduced pressure or equilibria more challenging. For example, in a study by Engel Clough and Driver (1985), about half of students aged 11-13 (n=84) described vacuums as actively sucking.

Students often think that fluids can only exert a pressure when they are moving, and assume that the pressure is in the direction of motion ( Séré, 1986; Driver et al., 1994).

**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):

* Plastic cup or glass
* Laminated card – larger than the opening of the glass
* Water

**Demonstration**

Half-fill the glass and holding the card over the top of the glass, turn it over.

Remove the hand from under the glass and the card *should* hold the water in. It is advisable to do this over a sink.

For added drama, ask for a volunteer and position them facing the class and in front of the demonstration. Make sure the card is holding the water in the upturned glass and then position it over the volunteer’s head. Ask them to look up!

The volunteer should move from underneath the glass before you hold the card and turn the glass back over, in case there are any spills.

The lamination on the card makes sure it does not become soggy and fail during the demonstration.

**Expected answers**

Statements A and B are correct.

Statement C is wrong.

**How to respond - what next?**

The weight of the water in the glass is supported by the pressure of air pushing up on the bottom of the card. The pressure of air at the bottom of the atmosphere is enough to push up on the card with a force of about 50 N. (Air pressure also pushes down on the bits of card sticking out from the glass, which has been accounted for in the calculation).

Air pushes on the card because of the movement of air particles. Air particles can bash into the bottom of the card, but not the top surface that is covered by water. The force caused by water particles bashing into the top of the card is much smaller, it is typically less than one Newton. Added to the weight of the water, the total downward force on the card is much less than the upwards force caused by air pressure.

There is no mechanism to explain how the air particles in air gap at the top of the inverted glass can *pull* up on the water. This can be demonstrated by removing the card!

If students have misunderstandings about how air pressure can push up with enough force on the bottom of the card to keep the water in the glass, it can help to convince them that it works, first of all, by demonstrating the effect. The effect can also be modelled for students by throwing ping-pong balls at one side of a piece of card held by a student. Careful questioning should elicit the understanding that if enough ping-pong balls (particles) were thrown at the card each second, there would be enough force to hold it in place against an upturned glass.

The size of push on the card, in the original demonstration, shows us that there are *very* many air particles pushing on it.

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

* Response activity: Pressure can

**Acknowledgments**

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Images: Peter Fairhurst (UYSEG).

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