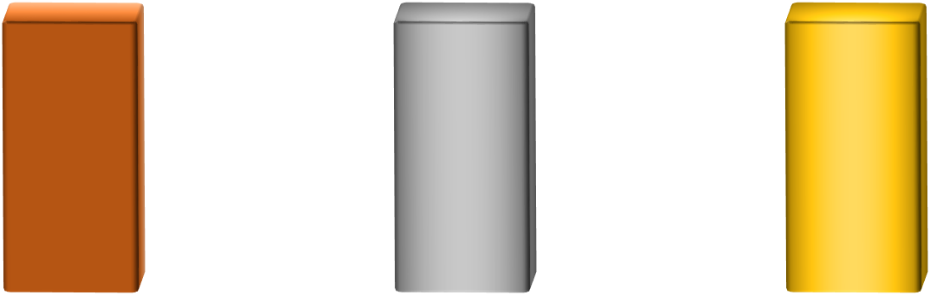
**Density by numbers**

**1.** Which block has the biggest density?

****

**C**

**B**

**A**

Mass 1344 g

Volume 150 cm3

Mass 1208 g

Volume 150 cm3

Mass 1310 g

Volume 150 cm3

**2.** Which block has the biggest density?

****

**C**

**B**

**A**

Mass 1000 g

Volume 141 cm3

Mass 1000 g

Volume 52 cm3

Mass 1000 g

Volume 47 cm3

**3.** Which block has the biggest density?



**C**

**B**

**A**

Mass 200 g

Volume 80 cm3

Mass 800 g

Volume 40 cm3

Mass 1300 g

Volume 160 cm3

*Physics > Big idea PMA: Matter > Topic PMA4: Particle explanations > Key concept PMA4.1: Density*

|  |
| --- |
| **Diagnostic question** |
| **Density by numbers** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Density, the mass of material in 1m3 or in 1cm3, is dependent on both the mass of its particles and their spatial arrangement. |
| Observable learning outcome: | Compare the density of objects that differ in both mass and volume. |
| Question type: | Simple multiple choice |
| Key words: | Density, mass, volume, weight |

|  |  |
| --- | --- |
| **P** | **PRIOR UNDERSTANDING**  This diagnostic question probes understanding of ideas that are usually taught at age 11-14, to aid transition from earlier stages of learning. |

**What does the research say?**

Teaching density from definitions and equations has consistently being shown to be less effective than methods that focus first on developing a qualitative understanding of density (Smith et al., 1997; Fassoulopoulos, Kariotoglou and Koumaras, 2003; Almuntasheri, Gillies and Wright, 2016; Hashweh, 2016).

A common misunderstanding amongst students is that mass (weight) and density are the same thing. This is perhaps linked to a tendency to define matter (including density) in terms of tangible properties that can be sensed. Mass (weight) and volume can both be sensed and directly measured. Mass and volume can also be defined as extensive quantities because they change with the amount of material. Density, by contrast, is an intensive quantity because it does not change with the amount of material (Smith, Snir and Grosslight, 1992). Intensive properties cannot be measured directly and are therefore harder to understand.

In a study of (n=296) 12- to 15-year-olds Fassoulopoulos et al. (2003) found that 54% were able to describe density using the correct scientific understanding. These students used phrases like ‘it is heavy for its size’, or ‘it has more mass for the same volume’. By contrast 24% of students in the study sometimes applied an understanding of density that showed they thought it changed in proportion to the amount of a substance.

A focus on developing qualitative reasoning can help students to bridge the gap between their starting conceptions and more formal quantitative reasoning. This might start with an understanding that if one of two objects of equal size is heavier, it is made of a heavier kind of material. Second, that if two objects have the same weight but are each a different size, the smaller one is made of a heavier kind of material. Third, if two objects are made of the same kind of material, they have the same density because equal-sized pieces would have the same weight. (Smith et al., 1997)

**Ways to use this question**

Students should complete the questions 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.

The answers to the questions will show you whether students understood the concept sufficiently well to apply it correctly.

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.

**Expected answers**

1. A

2. C

3. B

**How to respond - what next?**

These questions address the gap between qualitative thinking about density and quantitative understanding.

Question 1 should be answered correctly even if some students have the common misunderstanding that mass (weight) is equivalent to density.

Question 2 requires students to think of density as a concentration of mass: the same mass in a smaller volume. A few who think density represents the amount of a material may choose option A.

Question 3 requires students to apply their understanding of density and use proportionate thinking. It is not necessary to calculate a density for each block. Block B has more mass than block A in a smaller volume, so block B has a higher density than block A. Block C has nearly two times the mass as block B, but this mass is spread over four times the volume, so block C is less dense than block B.

If students have misunderstandings about comparing the density of objects that differ in both mass and volume, it can help to actively engage students in thinking about how volume plays a role in determining density. Careful questioning should elicit the understanding that equal sized blocks have more density if they contain more mass and that a block has more density than another if it contains the same mass in a smaller volume.

Giving students the opportunity to work in pairs or in small groups to explain, in their own words, why block B in question three has more density than the other blocks can help build and consolidate understanding. Providing further examples, similar to question three, can be used to strengthen links between students’ quantitative understanding and more formal quantitative calculations of density.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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