**Railway sleepers**

Sleepers hold railway tracks in place.

They make sure that the tracks are fixed at the right distance apart.

Railway sleepers can be made of wood or concrete.



*Fill in the gaps to describe the difference between each type of railway sleeper.*

*You should only use the words* ***mass*** *and* ***density****.*

**Mass and density**

A concrete railway sleeper has more \_\_\_\_\_\_\_ than a wooden sleeper that is the same size. Concrete has a bigger \_\_\_\_\_\_\_ than wood. It has more \_\_\_\_\_\_\_ in the same volume.

A concrete railway sleeper with the same \_\_\_\_\_\_\_ as a wooden one is thinner in the middle and has a smaller volume.

A wooden railway sleeper is hard to lift up because it has a big \_\_\_\_\_\_. If it is cut into different sized pieces, each piece will have a different \_\_\_\_\_\_\_. The \_\_\_\_\_\_\_ of each piece will be the same.

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

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| **Diagnostic question** |
| **Railway sleepers** |

**Overview**

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| 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: | Describe characteristics of objects or substances with high (or low) densities. |
| Question type: | Focused cloze |
| Key words: | Density, mass, volume, weight |

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| **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?**

A common misunderstanding amongst students is that 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.

Modelling clear explanations for density can raise awareness in students of the need to be explicit about volume (Seah, Clarke and Hart, 2015). Students need to be actively engaged in thinking about how volume plays a role in determining density and given opportunity to explain density in their own words. Asking students to elaborate on answers in class or small-group discussions allows them to rehearse their use of the language of scientific explanation, as well as indicating their ability to do so.

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 activity individually as a pencil and paper exercise. The large text on the worksheet allows it to be copied A5 size, which fits a standard exercise book.

How students fill in the gaps will show you whether they 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 sentences 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**

**Mass and density**

A concrete railway sleeper has more **mass** than a wooden sleeper that is the same size. Concrete has a bigger **density** than wood. It has more **mass** in the same volume.

A concrete railway sleeper with the same **mass** as a wooden one is thinner in the middle and has a smaller volume.

A wooden railway sleeper is hard to lift up because it has a big **mass**. If it is cut into different sized pieces, each piece will have a different **mass**. The **density** of each piece will be the same.

**How to respond - what next?**

This question addresses the misunderstanding that mass (weight) and density are the same thing. It takes students through a qualitative development of understanding density, starting with the idea that the heavier of two objects of equal volume has a bigger density. The second paragraph introduces the idea that the smaller of two objects with the same mass has a bigger density. The final paragraph checks understanding that if two objects are made of the same kind of material, they have the same density because equal-sized pieces each have the same mass.

If students have misunderstandings about describing characteristics of objects or substances with high (or low) densities, it can help to actively engage students in thinking about how volume plays a role in determining density and to give them opportunity to explain the answers to each of these paragraphs in their own words.

A useful exercise is to start with two identical blocks. Careful questioning should elicit the idea that each block has the same mass, the same volume and the same density as the other one. Each has the same mass for a given volume. Adding the blocks together doubles volume and doubles mass, but the density of the material is the same because neither block has been altered, which means the mass of a given volume remains the same.

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**References**

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