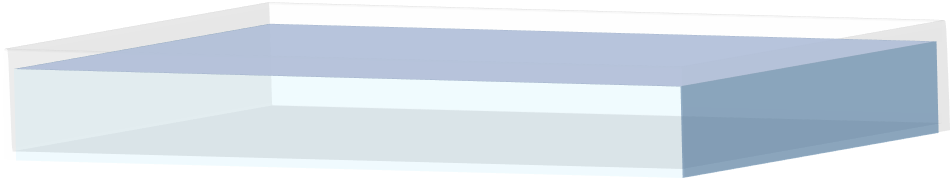
**Liquid refraction**

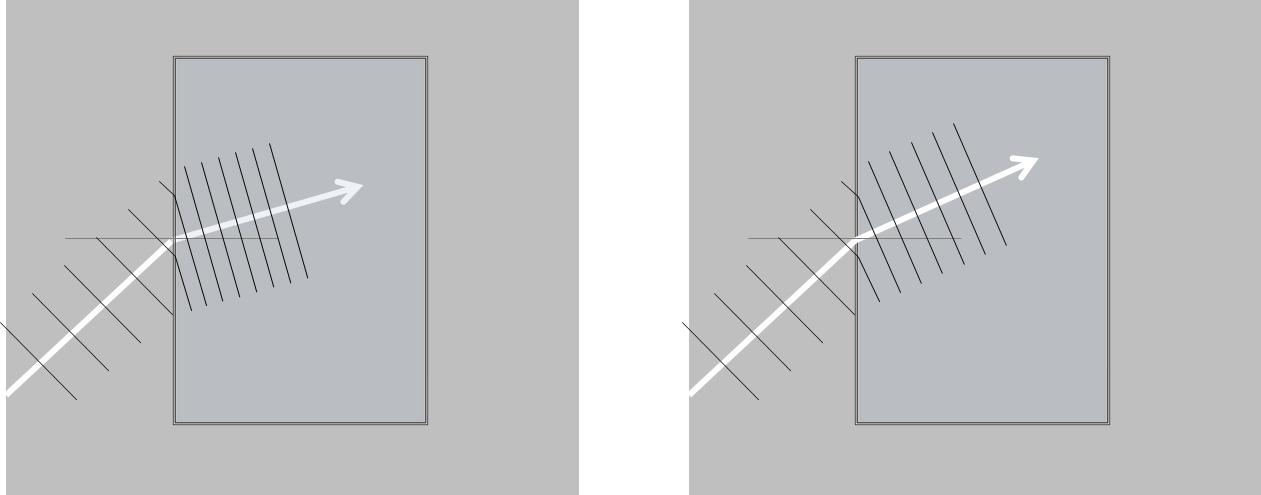
A clear plastic box is filled with a liquid.

It can be used to investigate how different liquids refract light.



A ray of light is shone through two different liquids.

**a.** As it *leaves* each liquid, from which one will it be refracted the most?



**A**

**B**

**b.** What is the best reason for your answer to *part a*?

*Put a tick (✓) in the box next to the best answer.*

|  |  |  |
| --- | --- | --- |
| **A** | The wave speed will change most at the boundary. |  |
|  |  |  |
| **B** | The wavelength will change most at the boundary. |  |
|  |  |  |
| **C** | The wavelength is longest in this liquid. |  |
|  |  |  |
| **D** | The wave refracted most when it entered this liquid. |  |

*Physics > Big idea PSL: Sound, light and waves > Topic PSL6: Wave properties of light > Key concept PSL6.1: Refraction and dispersion*

|  |
| --- |
| **Diagnostic question** |
| **Liquid refraction** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | Light has wave properties, which allows it to be refracted at a boundary between one transparent medium and another in which it travels at a different speed. |
| Observable learning outcome: | Compare the refraction of light at the boundary of different pairs of transparent media. |
| Question type: | Two-tier multiple choice |
| Key words: | Refract, refraction, wavelength, wavefront |

|  |  |
| --- | --- |
| **B** | **BRIDGING**  This diagnostic question probes understanding of ideas that are usually taught at age 16-19, to build a bridge to later stages of learning. |

**What does the research say?**

Wavefront diagrams can be used to explain how light is refracted, but students struggle to interpret these. They find it hard to visualise how the wave pattern moves out from the source, or relate it to a photograph [or a real wave] (Knight, 2004).

Wosilait et al. (1999) suggest that the process of developing a wave model of light should begin by using the context of water waves. This gives students the opportunity to develop and consolidate their understanding of wavefront diagrams by articulating what happens at different points in space as a wave moves forwards (Knight, 2004). This understanding could then be extended to explain refraction.

As with mechanical waves, the speed of a light wave is determined almost entirely by the medium it is passing through. The higher the optical density of a transparent medium, the slower the speed of light through it. Changing the speed of a light wave does not alter its frequency.

Explanations of refraction should include rays, but also include wavefronts and ideas about changing speed and therefore changing wavelength (Sengoren, 2010).

**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 follow-on question will give you insights into how they are thinking and highlight specific misconceptions that some may hold.

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**

a. A

b. A

**How to respond - what next?**

As it entered each liquid, light was refracted most when it entered liquid A. It is the *difference* in properties between the air and this liquid that makes the light refract. The increase in speed of light as it leaves each liquid will be the same as the decrease in speed when it entered them, so it will also refract the most as it leaves liquid A. Liquid A is optically more dense than liquid B (and has a higher refractive index).

More precisely, the greater fractional difference between the speed at which light travels in air and its speed in another medium, the more it refracts as it crosses a boundary between that medium and air.

B The wavelength willchange the most as light leaves liquid A, but this is caused by the speed of light increases by a greater amount, so option A is a better *reason*.

D As light leaves the liquid, it will refract by the same angle as it was bent when it entered, but in the opposite direction. Again, this is a description of what happens and not a cause.

C Some students may think that the longer wavelength in liquid B shows that the light is travelling more slowly in liquid B than in liquid A, and connect this to a bigger change in speed as it leaves liquid B.

Other students may think both waves are travelling at the same speed in each liquid. These students may reason that the longer wavelength of light in liquid B will give the light, on the side of a wavefront leaving liquid B first, more time to move at a higher speed to change the direction of the light than a wavefront in liquid A.

If students have misunderstandings about comparing the refraction of light at the boundary of different pairs of transparent media, it can help to demonstrate how light refracts by using a metre rule to represent a wavefront.

As the metre rule crosses a boundary (perhaps a line drawn on a table) it can be shown that it is the *difference* in speed of each end (one on either side of the boundary) that turns the direction of the metre rule. And that this is independent of how close behind the next metre rule is, or how frequently the metre rules cross the boundary.

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

* Response activity: Turning expectations

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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Sengoren, S. K. (2010). How do Turkish high school graduates use the wave theory of light to explain optics phenomena? *Physics Education***,** 253-263.

Wosilait, K., et al. (1999). Addressing student difficulties in applying a wave model to the interference and diffraction of light. *American Journal of Physics,* 67 (7)**,** S5.