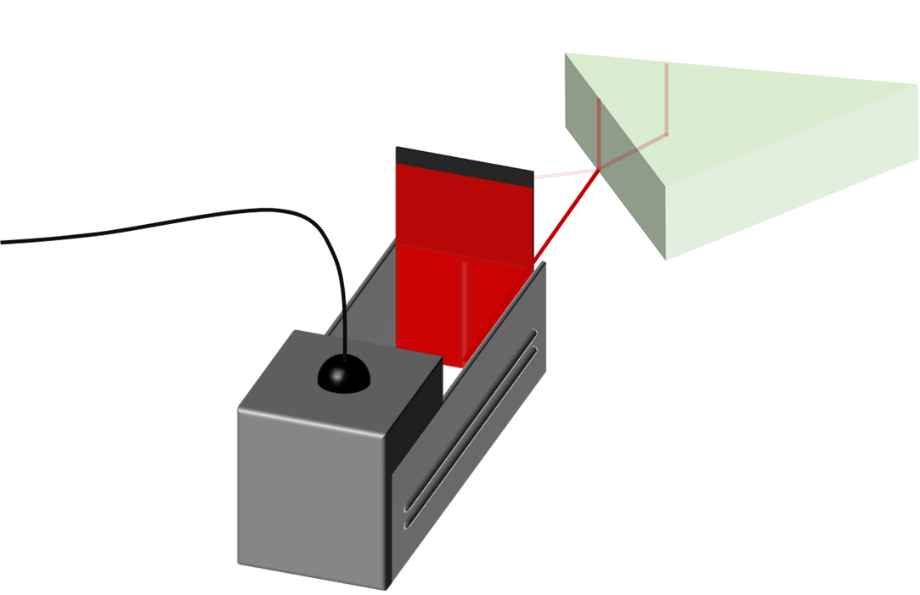
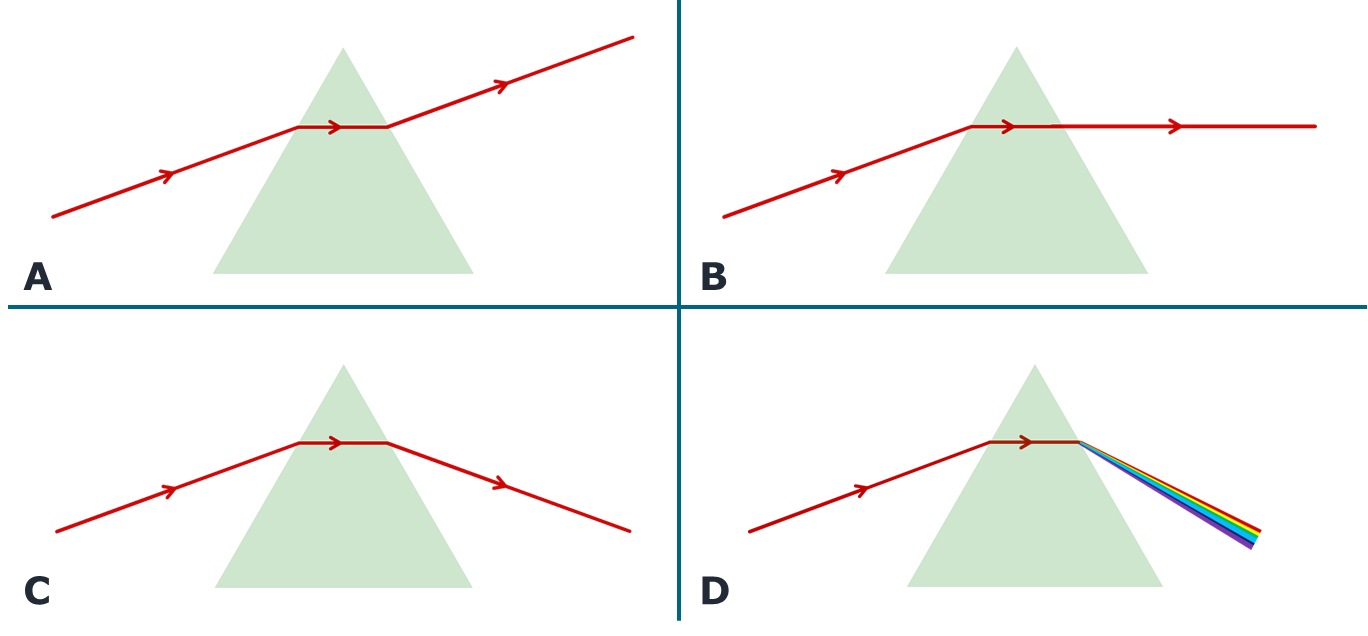
**Refracting red**

A red filter is fitted to a ray lamp.

A ray of red light is shone through a glass prism.

Which diagram best shows how the red light is refracted?



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

|  |
| --- |
| **Diagnostic question** |
| **Refracting red** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The frequency of a light wave determines the colour of the light. When light refracts at a boundary, the size of the angle by which each different colour changes direction is different. |
| Observable learning outcome: | Use ray diagrams to show how red light refracts as it passes through a prism with three 60o angles. |
| Question type: | Simple multiple choice |
| Key words: | Refract, refraction, dispersion, spectrum |

|  |  |
| --- | --- |
| **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?**

When students learn about light, rays are typically used to describe refraction and reflection, but to explain these requires using wave theory (Fyttas, Komis and Ravanis, 2013). This is why students have difficulty using ray diagrams to make predictions or to explain observed phenomena (Galili, Bendall and Goldberg, 1993).

A common strategy for teaching students about refraction is to demonstrate examples of refraction phenomena and to explain the observations using ray diagrams that show how light is bent by glass blocks. In this approach students may use a ray box to explore how light travels through a parallel sided glass block to understand the nature of refraction. They change the angles of incidence to establish: a change of direction only occurs at an interface; light travelling perpendicular to the interface is not refracted; and light bends towards the ‘normal’ when entering an optically more dense medium and vice versa (Davenport, 2021).

In a study of (n=213) Greek students age 14-15, who had previously studied refraction, Fyttas et al. (2013) found that significant numbers thought wrongly that light was wholly reflected at a boundary or that it was refracted the wrong direction. About half thought that light continued in a straight line at a boundary between air and glass, because glass is transparent.

In a study of 13-year-olds (n=150), 72% did not think that white light was a mixture of different colours (Zylbersztajn and Watts, 1982; Driver et al., 1994). In fact, before encountering ‘white light’ in science lessons fewer than 10% of 13- to 15-year-olds (n=22) understood what ‘white light’ was (Haagen-Schutzenhofer, 2017). Students often regard white light as ‘pure light’ that is free of any tinge. More than half of a sample of 13- to 16-year-olds (n=166) considered colour to be different to light and something that is added to light (Galili and Hazan, 2000).

**Ways to use this question**

Students should complete the question 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 question 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 answer**

C

**How to respond - what next?**

To answer this question correctly, students need to recall the rules for refraction and apply them correctly. As the angle of the surface on either side of the prism is different, drawing a normal line at each surface is very helpful. When normal lines are added, the ray of light in diagram C clearly bends towards the normal line on entering the prism and away from the new normal line as it exits.

A The first diagram may suggest students are recalling the ray diagram for refraction through a rectangular glass block and are applying it wrongly, without thinking about the rules for refraction. Alternatively, they may be applying the rules without regard to the normal lines; and consider that in this diagram the emergent ray is bending in the opposite direction to the ray shone into the prism.

B A few students may consider the ray passes through the second surface without refraction because it is transparent, although this contradicts it bending at the first boundary.

D Some students may recall the creation of a spectrum of light from earlier in their education and apply that wrongly to this question. It is relatively common for students to think that a (colourless) prism can add colour to light.

If students have misunderstandings about using ray diagrams to show how red light refracts as it passes through a prism with three 60o angles, it can help to demonstrate how normal lines can be drawn at each surface, so the rules of refraction can be applied to *work out* what happens.

The BEST response activity *Yellow light* from key concept: *PSL2.2 Seeing in colour* could be used to challenge the misunderstanding that red light can be split into the colours of the rainbow.

To consolidate understanding, students could be given the opportunity to use the rules of refraction to draw rays of light passing through a range of different shaped prisms.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Davenport, C. (2021). Waves. In de Winter, J. & Hardman, M. (eds.) *Teaching Secondary Physics.* 3rd ed. London: Hodder Education.

Driver, R., et al. (1994). *Making Sense of Secondary Science: Research into Children's Ideas,* London, UK: Routledge.

Fyttas, G., Komis, V. and Ravanis, K. (2013). Ninth grade students' mental representations of the refraction of light: didactic implications. *Mexican Journal of Physics,* 59**,** 133-139.

Galili, I. and Hazan, A. (2000). Learners' knowledge in optics: interpretation, structure and analysis. *International Journal of Science Education,* 22(1)**,** 57-88.

Haagen-Schutzenhofer, C. (2017). Students' conceptions on white light and implications for teaching and learning about colour. *Physics Education,* 52.

Zylbersztajn, A. and Watts, D. M. (1982). Throwing some light onto colour. Guildford: Mimeograph, University of Surrey.