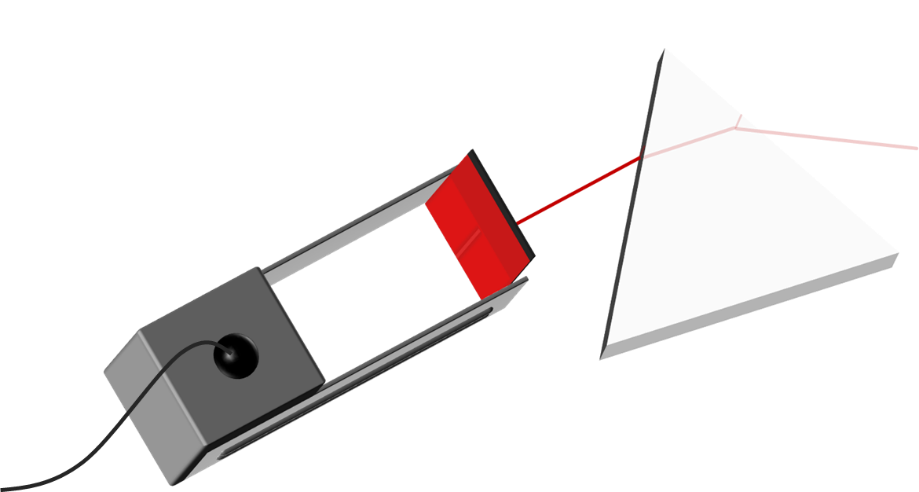
**Prism rules**

Red light is shone through a glass prism.

The glass is optically more dense than air.

Why does red light refract as it passes through the prism?

**To do:** connect the statements to make three sentences that explain what happens.

Light inside the prism …

Light entering the prism …

Light leaving the prism ...

and is bent away from the normal line.

and is bent towards the normal line.

and moves in a straight line.

slows down ...

speeds up …

keeps the same speed ...

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

|  |
| --- |
| **Diagnostic question** |
| **Prism rules** |

**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: | Explain why red light refracts in the way it does through a prism with three 60o angles. |
| Question type: | Linking ideas |
| Key words: | Refract, refraction, normal, optically more dense |

**What does the research say?**

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.

Fredlund, Airey and Linder (2012) found that even experienced undergraduate students tend to attempt to explain refraction using ray diagrams first, and wave theory only when this approach fails. They postulate that this is because ray diagrams are used more often and students are most familiar with them. This is perhaps similar to the way, described by Bing and Redish (2012), that students often approach calculations – by quoting a remembered equation and (sometimes blindly) trying to fit in the given quantities, rather than by examining the situation to see what approach is most appropriate.

This suggests that it could be helpful to scaffold answering questions about refraction using general rules based on wave theory and the speed of light in different media.

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It is best done as a pencil and paper exercise.

Students should look at the picture and follow the instructions on the worksheet. Listening in to the conversations of each group will often give you insights into how your students are thinking. Each member of a group should be able to report back to the class.

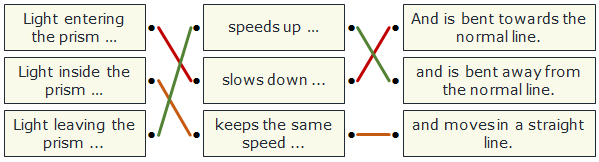
* It can be helpful to prompt students or groups of students who do not have the correct answer to draw normal lines onto the picture, in the appropriate places.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of why the ray of red light refracts the way it does as it moves through the prism.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in each group. For example, you may choose to select a student with strong prior knowledge as the scribe, and forbid them from contributing any of their own answers. They may question the others and only write down what they have been told. This strategy encourages contributions from more members of each group.

**Expected answers**



**How to respond - what next?**

As it enters the prism, light refracts towards the normal line because it moves at a slower speed through the glass. At the opposite face, the light refracts away from the normal because it moves through the air at a faster speed.

The fact that sound waves and other mechanical waves travel faster in solids than in gases, may prompt some students to have the misunderstanding that light travels faster in solid glass because the glass is optically more dense than air. Unlike mechanical waves, light can travel through the vacuum of empty space, which suggests the mechanism by which it propagates is a different one.

Some students may think that the ray leaving the prism refracts towards the normal line, because this will make the ray bend back towards the direction in which the light was moving before it entered the prism. Others may wrongly apply what they saw for a rectangular glass block, which is that ‘light is refracted one way and then the other way’ as it enters and leaves the prism.

Many students are likely to omit drawing normal lines at 90o to each surface. Drawing these lines is very helpful in applying the rules of refraction accurately.

If students have misunderstandings about explaining why red light refracts in the way it does through a prism with three 60o angles, it can help to scaffold answers to the question. Students can be supported in drawing normal lines to each surface of the prism at the points where the ray enters and leaves; and be guided into applying the general rules of refraction at each surface.

Students could be challenged to explain why light does not refract overall in the same way as it does when it passes through a rectangular glass block.

It may be appropriate to give some students the opportunity to draw wavefront diagrams to show how red light bends as it slows down and then speeds up as it passes across the boundaries between the prism and the air.

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

* Response activity: Prism blues

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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