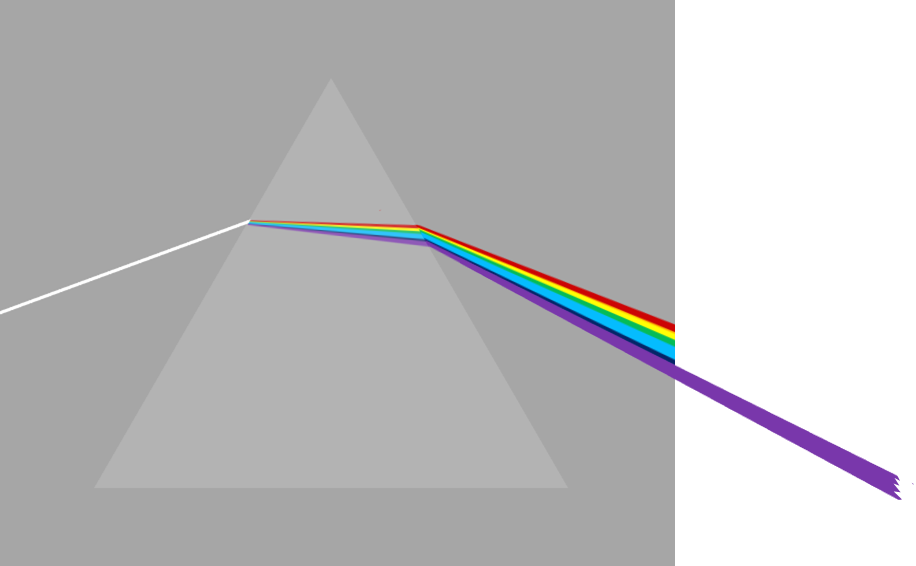
**The colour violet**

Violet light refracts because it has wave properties.

Different colours within white light refract at different angles.



Violet light refracts more than blue light.

How does **violet** light compare to **blue** light?

*For each statement, tick (✓)* ***one*** *column to show what you think.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** | Violet light travels faster in glass. |  |  |  |  |
| **B** | Violet light travels faster in air. |  |  |  |  |
| **C** | Violet light has a higher frequency. |  |  |  |  |
| **D** | Violet light has a longer wavelength. |  |  |  |  |

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

|  |
| --- |
| **Diagnostic question** |
| **The colour violet** |

**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: | Compare different colours of pure light. |
| Question type: | Confidence grid |
| Key words: | Refract, frequency, wavelength, prism |

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

The speed of a mechanical wave depends on the properties of the medium it is passing through and is independent of the wave’s frequency or the size of disturbance (amplitude). In a study of (n=598) students aged 15 to 16, Caleon and Subramaniam (2010) found that over 70% held the common misunderstanding that the speed of a mechanical wave depends on frequency. Studies by Tongchai et al (2011) of (n=324) senior high school students, Wittmann, Steinberg and Redish (1999) of (n=92) students enrolled onto a university physics course and Tumanggor et al (2019) of trainee physics teachers (n=35) all found similar results.

For light waves, the higher the optical density of a transparent medium, the slower the speed of light through it. However, *the speed of light through a transparent medium is also affected by its frequency*.

All colours of light travel at the same speed in a vacuum, but the frequency of each colour determines how quickly it moves through other transparent media. This is because the way that light photons interact with particles in a medium is dependent on their frequency. This fact, that the speed of light in a transparent medium depends both on the medium *and* on the frequency of the light, distinguishes light waves from mechanical waves and is rarely brought to the notice of students. This lack of awareness can lead to confusion.

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

Students should complete the confidence grid 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.

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**

Statement C is right, statements A, B and D are wrong.

**How to respond - what next?**

In air, violet light travels at the same speed as all other colours of light, but as it enters glass it refracts more than blue light. This shows that it moves slower than blue light in glass, just as blue light moves slower than red. Following the same pattern as red and blue light, violet light has a higher frequency than blue light and a correspondingly shorter wavelength.

A Some students may have a misunderstanding that the speed of a light wave is determined solely by the medium it is travelling through and that all colours of light travel at the same speed in glass. This is true for mechanical waves, but not for light waves.

B In air, all colours of light travel at 3.00 x 108 m/s because light interacts very weakly with particles in air. (More accurately, the speed of violet light in air is very slightly *slower* than blue light.)

D For light moving through a particular transparent medium: the higher the frequency of light, the shorter the wavelength.

If students have misunderstandings about comparing different colours of pure light, it can help to use diagnostic questions and response activities from earlier steps in the BEST learning progression in which this diagnostic question is found: *PSL6.1.2 Explaining dispersion* to develop an understanding of the comparative properties of red and blue light.

Careful questioning should lead students to the understanding that: violet light is refracted more than blue in comparison to red light, and that the properties of violet light compare to those of red light in the same way as the properties of blue light to red, only more so.

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

* Response activity: Light comparison

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Images: Peter Fairhurst (UYSEG).

**References**

Caleon, I. S. and Subramaniam, R. (2010). So Students Know What They Know and What They Don't Know? Using a Four-Tier Diagnostic Test to Assess the Nature of Students' Alternative Conceptions. *Research in Science Education,* 40 (3)**,** 313-337.

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

Tongchai, A., et al. (2011). Consistency of students' conceptions of wave propogation: Findings from a conceptual survey in mechanical waves. *Physical Review Special Topics Physics Education Research,* 7(2)**,** 11.

Tumanggor, A. M. R., et al. (Year) Published. Using four-tier diagnostic test instruments to detect physics teacher candidates’ misconceptions: Case of mechanical wave concepts. The 5th International Seminar on Science Education, 2019 Yogyakarta, Indonesia Journal of Physics: Conference Series, Institute of Physics.

Wittmann, M. C., Steinberg, R. N. and Redish, E. F. (1999). Making Sense of How Students Make Sense of Mechanical Waves. *The Physics Teacher,* 37**,** 15-21.