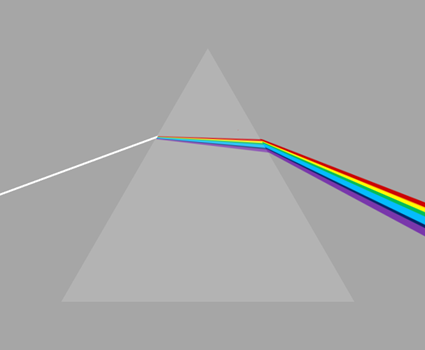
**Rainbow light**

If white light passes through a prism correctly, it can form a rainbow.

Light refracts at each boundary of the prism.

Different colours within the white light refract at different angles.



White light is made of many colours, including red and blue.

Red light has a longer wavelength and a lower frequency than blue.



Why can white light be split into the colours of the rainbow?

*Pick* ***one*** *statement in each row to explain the reason.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | White light contains a range of different colours. | | White light contains all the colours we see. | |
| 2 | In air, all colours of light travel at the same high speed. | In air, red light travels faster than blue light. | | In air, blue light travels faster than red light. |
| 3 | In glass, all colours move at the same slower speed. | Light moves slower in glass, but red light moves faster than blue. | | Light moves slower in glass, but blue light moves faster than red. |
| 4 | The greater the frequency of light at a boundary, the bigger the angle it  refracts at. | | The greater the change of speed of light at a boundary, the bigger the angle it refracts at. | |

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

|  |
| --- |
| **Response activity** |
| **Rainbow light** |

**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 blue light refracts more at a boundary than red light.  Predict how blue light refracts as it passes through a prism with three 60o angles. |
| Activity type: | Explanation story |
| Key words: | Refraction, frequency, wavelength, prism |

This activity can help develop students’ understanding by addressing the sticking-points revealed by the following diagnostic questions:

* Diagnostic question: Refraction blues
* Diagnostic question: Double refraction

**What does the research say?**

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).

The speed of a wave depends on the properties of the medium it is passing through and, for mechanical waves, 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 activity**

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

Students should read the statements 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.

Feedback from each group can be used, with careful teacher questioning, to bring out a clear description or explanation of the science.

*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.

NB in any class, small group discussions typically improve over time and a persistence with this strategy is often very successful in the medium to long term.

**Expected answers**

1. White light contains a range of different colours of light.
2. In air, all colours of light travel at the same high speed.
3. Light moves slower in glass, but red light moves faster than blue.
4. The greater the change of speed of light at a boundary, the bigger the angle it refracts at.

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Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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