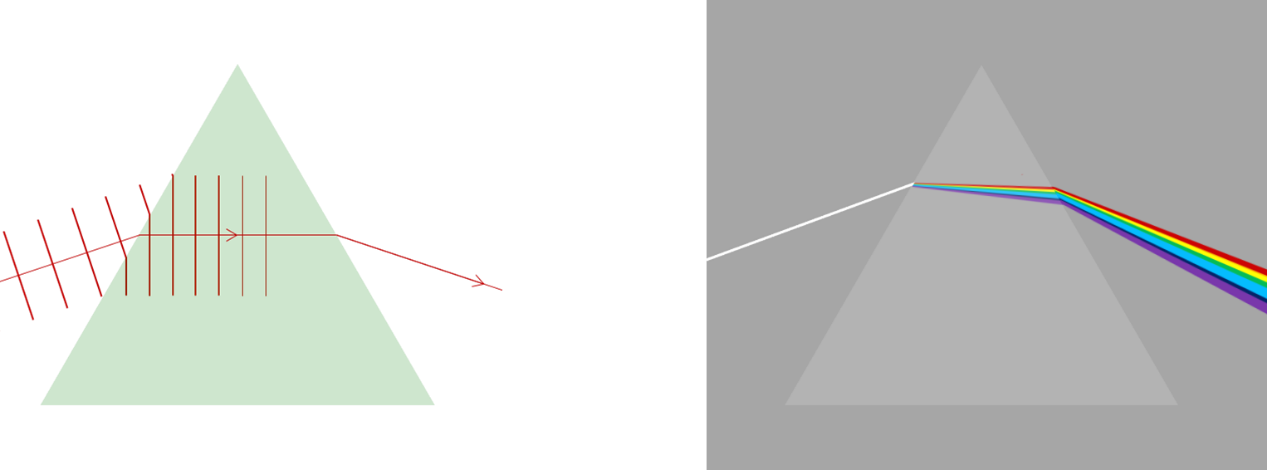
**Making rainbows**

Red light refracts as it passes through a prism because it has wave properties.

Different colours within white light refract at different angles.



The following passage explains why red light refracts as it passes through a prism.

Use your understanding of white light to add more sentences that explain how a rainbow is made.

Red light can be represented as a series of wavefronts moving forward.

* One end of each wavefront reaches the prism before the other.
* The wavefront in glass moves more slowly.
* The other end of the wavefront travels faster until it reaches the boundary.
* This swings the light wave round and it moves forward in a different direction.
* The red light is refracted towards the normal line.

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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*

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

**Overview**

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| --- | --- |
| 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 passage 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 answer**

* Other colours are slowed more by the glass than red light.
* They are refracted more than red light as white light enters the prism.
* They are each refracted more than red light when they leave the prism too.
* Violet coloured light is slowed the most and is refracted the most; and red light is slowed and refracted the least.
* This splits the white light into each of the colours it contains.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

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