

**Light comparison**

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

Different colours within white light refract at different angles.

**To do:**

Fill in the boxes to answer the questions:

* What do green light and yellow light have in common?
* How are they different?

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

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| **Response activity** |
| **Light comparison** |

**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: | Compare different colours of pure light. |
| Activity type: | Application and practice |
| Key words: | Refract, frequency, wavelength, electromagnetic wave |

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

* Diagnostic question: The colour violet

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| **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 activity**

This activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should answer the question in pairs or small groups.

Listening to individual groups as they work often highlights any difficulties they might have. These can often be overcome, through a whole class clarification or redirection part way through the activity.

Asking students to share their answer is a useful check. After a group has fed back, it might be helpful to model an even better answer. You could do this, for example, by asking another group to add to, or clarify, the first observation. Then ask another group to sum up the important part of the observation, and so on.

*Differentiation*

If some students are working with a teaching assistant, then a list of prompt questions for the TA could help to make this activity more purposeful.

**Expected answers**

Similarities might include that both: have wave properties; can be seen (detected with the eye); pass through transparent materials; travel at the ‘speed of light’ in air; move slower in glass or other optically dense transparent media; and are electromagnetic waves.

Differences of green light might include that it: has a higher frequency; has a shorter wavelength; moves slower in glass or other optically dense transparent media; and it refracts more.

Differences of yellow light might include that it: has a lower frequency; has a longer wavelength; moves less slowly in glass or other optically dense transparent media; and it refracts less.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Stars: Peter Fairhurst (UYSEG).

**References**

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