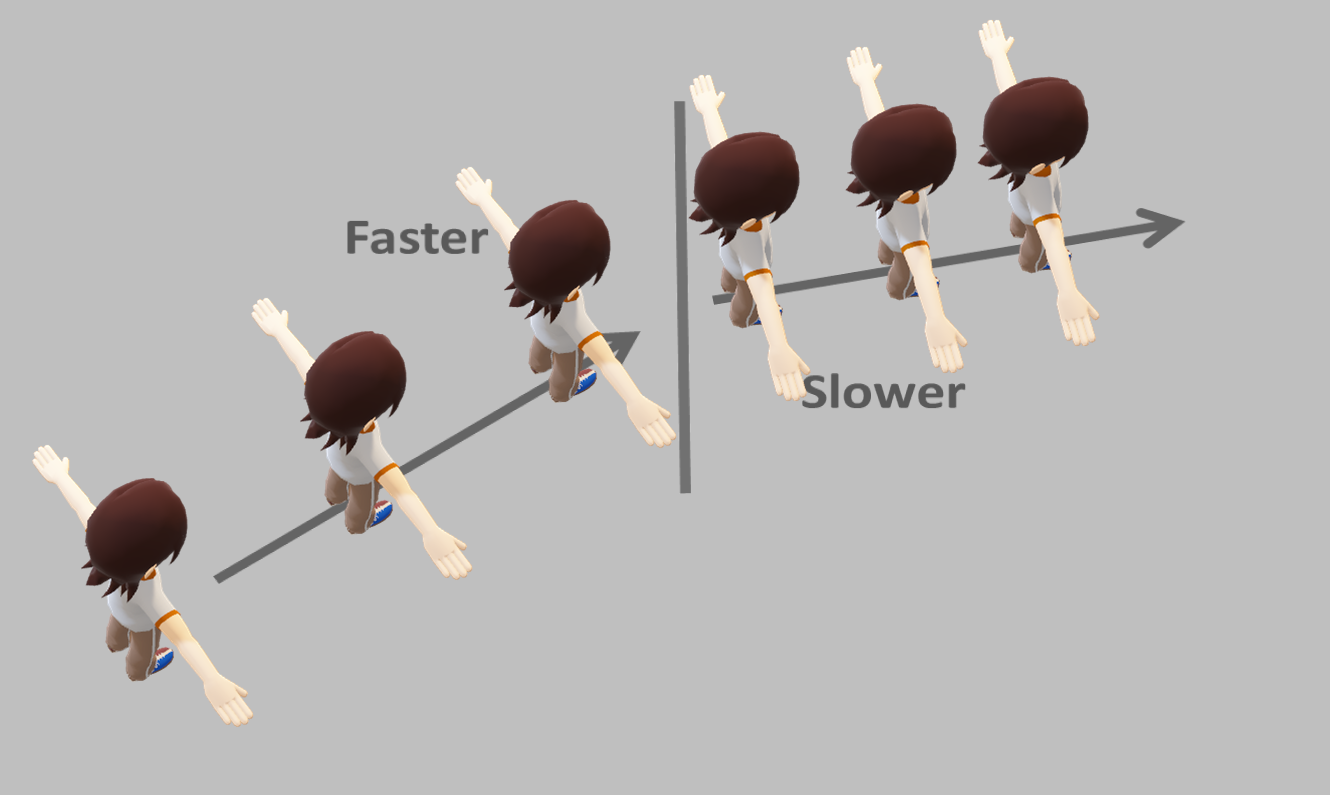
**Modelling refraction**

Albert is modelling refraction.

He wants to show why a wave can bend when it moves across a boundary.



**To answer**

**1.** State three ways in which this is a good representation of refraction.

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**2.** State three ways in which this is not an accurate representation of refraction.

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**3.** Use the wave model to explain how light refracts at a boundary between air and glass.

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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*

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| --- |
| **Response activity** |
| **Modelling refraction** |

**Overview**

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| --- | --- |
| Learning focus: | Light has wave properties, which allows it to be refracted at a boundary between one transparent medium and another in which it travels at a different speed. |
| Observable learning outcome: | Use wavefront diagrams to show how water waves refract.  Use a wave model to explain how light refracts. |
| Activity type: | Critiquing a representation |
| Key words: | Refract, refraction, wavefront, crest, frequency, wavelength |

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

* Diagnostic question: Refracting water waves
* Diagnostic question: Representing light
* Diagnostic question: Refracting light

**What does the research say?**

Wavefront diagrams can be used to explain how light is refracted, but students struggle to interpret these. They find it hard to visualise how the wave pattern moves out from the source, or relate it to a photograph [or a real wave] (Knight, 2004).

Wosilait et al. (1999) suggest that the process of developing a wave model of light should begin by using the context of water waves. This gives students the opportunity to develop and consolidate their understanding of wavefront diagrams by articulating what happens at different points in space as a wave moves forwards (Knight, 2004). This understanding could then be extended to explain refraction.

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

**Ways to use this activity**

Students should complete this activity in pairs or small groups, and the focus should be on the discussions. It is through the discussions that students can check their understanding and rehearse their explanations.

Philosophically science can be said to be a description of the ‘best model’ we have for the world. In this activity students should identify ways in which this particular model is a good representation of the real world, and ways in which it is not.

Students should work together to answer the questions on either the worksheet or the PowerPoint. Giving each group one worksheet to complete between them is helpful for encouraging discussion, but each member should be able to report back to the class. Listening in to the conversations of each group will often give you insights into how your students are thinking.

Ending with the students completing the worksheet or questions from the PowerPoint individually, might help them to consolidate their learning.

*Differentiation*

You may choose to use simplified worksheets for some students, for example with gaps to fill in so they can focus on the science. In some situations, it may be more appropriate for a teaching assistant to read and/or scribe for one or two students.

**Expected answers**

1 Albert’s arms show how a wavefront moves forward.

As he walks forward, his right hand reaches the boundary and slows down before his left hand.

His left hand keeps moving more quickly for longer and swings him round.

2 Albert is on his own and there should be lots of wavefronts moving forward.

As a wavefront crosses a boundary its shape is that of a bent straight line – Albert’s arms don’t bend in the same way.

Albert needs to think about what happens as he crosses the boundary and decide to change speed and direction. In refraction, these changes are automatic for a wavefront as it crosses a boundary, because of the change of medium it is travelling through.

3 Light has the properties of a wave. As a light wave moves from air into glass, it slows down in the glass. The side of the wavefront that meets the glass first slows down first. The side of the wavefront that reaches the glass last will travel faster for a short time until it reaches the glass. This swings the wavefront round and is moves forward through the glass in a new direction.

The light wave is refracted towards the normal line.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG) using an avatar from Microsoft PowerPoint.

**References**

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

Wosilait, K., et al. (1999). Addressing student difficulties in applying a wave model to the interference and diffraction of light. *American Journal of Physics,* 67 (7)**,** S5.