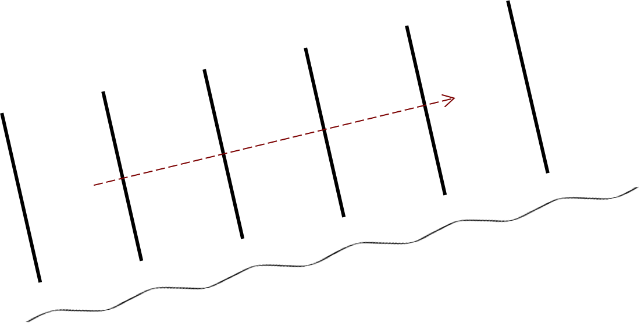
**Explaining refraction**

When light crosses a boundary between one transparent medium and another it can refract.

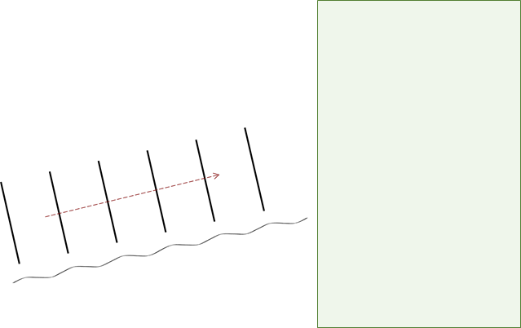
It refracts if it meets the boundary at the right sort of angle.

Light refracts because it has the properties of a wave.

**

Light can be represented as

a series of wavefronts moving forward.



**1.** Use *some* of these statements to explain how light

moving from **air into glass** can refract.

The wavefront in glass moves more slowly.

The wavefront in glass moves more quickly.

One end of each wavefront reaches the boundary before the other.

The other end of the wavefront travels faster until it reaches the boundary.

The other end of the wavefront travels more slowly until it reaches the boundary.

The wavefront in air moves more slowly.

The wavefront in air moves more quickly.

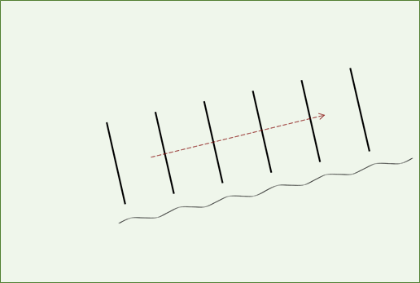
The light wave is refracted towards the normal line.

The light wave is refracted away from the normal line.

This swings the light wave round and it moves forward in a different direction.

**Start with:**

Light can be represented as a series of wavefronts moving forward …



**2.** Use *some* of these statements to explain how light

moving from **glass into air** can refract.

The wavefront in glass moves more slowly.

The wavefront in glass moves more quickly.

One end of each wavefront reaches the boundary before the other.

The other end of the wavefront travels faster until it reaches the boundary.

The other end of the wavefront travels more slowly until it reaches the boundary.

The wavefront in air moves more slowly.

The wavefront in air moves more quickly.

The light wave is refracted towards the normal line.

The light wave is refracted away from the normal line.

This swings the light wave round and it moves forward in a different direction.

**Start with:**

Light can be represented as a series of wavefronts moving forward ...

Explaining refraction cards

The wavefront in glass moves more slowly.

The wavefront in glass moves more quickly.

One end of each wavefront reaches the boundary before the other.

The other end of the wavefront travels faster until it reaches the boundary.

The wavefront in air moves more slowly.

The wavefront in air moves more quickly.

The light wave is refracted towards the normal line.

The light wave is refracted away from the normal line.

The other end of the wavefront travels more slowly until it reaches the boundary.

This swings the light wave round and it moves forward in a different direction.

Explaining refraction cards

The wavefront in glass moves more slowly.

The wavefront in glass moves more quickly.

One end of each wavefront reaches the boundary before the other.

The other end of the wavefront travels faster until it reaches the boundary.

The wavefront in air moves more slowly.

The wavefront in air moves more quickly.

The light wave is refracted towards the normal line.

The light wave is refracted away from the normal line.

The other end of the wavefront travels more slowly until it reaches the boundary.

This swings the light wave round and it moves forward in a different direction.

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

|  |
| --- |
| **Response activity** |
| **Explaining refraction** |

**Overview**

|  |  |
| --- | --- |
| 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 a wave model to explain how light refracts. |
| Activity type: | Explanation story |
| Key words: | Refract, refraction, wavefront, normal |

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

* 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**

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**

*Light moving from air into glass*

**1.** Light can be represented as wavefronts moving forward.

One end of each wavefront reaches the boundary 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 light wave is refracted towards the normal line.

*Light moving from glass into air*

**2.** Light can be represented as wavefronts moving forward.

One end of each wavefront reaches the boundary before the other.

The wavefront in air moves more quickly.

The other end of the wavefront travels more slowly until it reaches the boundary.

This swings the light wave round and it moves forward in a different direction.

The light wave is refracted away from the normal line.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Knight, R. D. (2004). *Five Easy Lessons: Strategies for Successful Physics Teaching,* San Francisco, U.S.A.: Addison Wesley.

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.