**Measuring refraction**

Light refracts as it enters a glass block.

Light refracts again as it leaves the glass block.

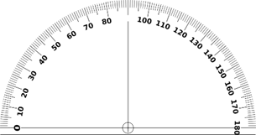
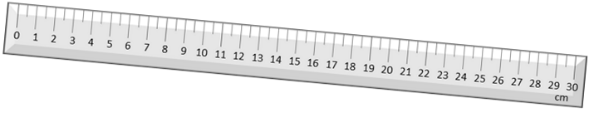
A ray lamp can be used to work out rules for refraction.

**Safety**

The power supply used mains electricity. Do not plug in if the plug is damaged or has loose wires.

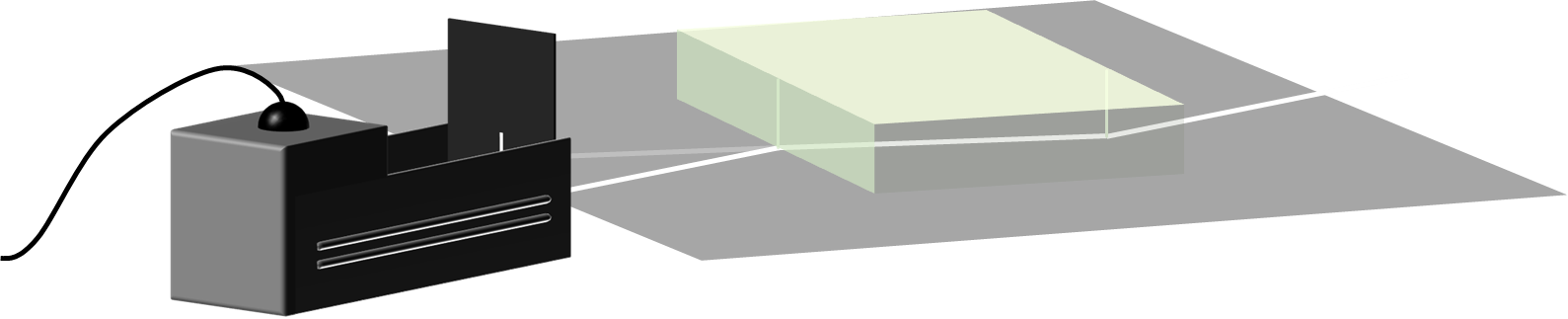
The ray lamp bulb may get very hot.

**Apparatus**

* ****Rectangular glass block
* Ray lamp and slit
* Power supply
* Ruler
* ****Protractor
* Large sheet of paper

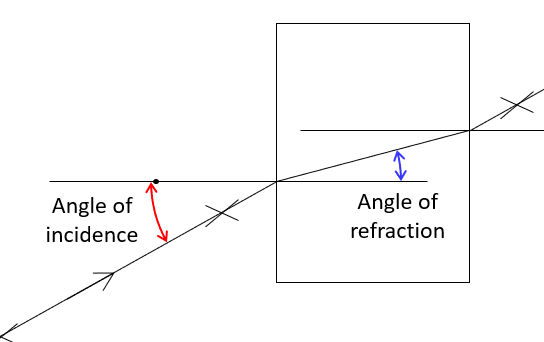
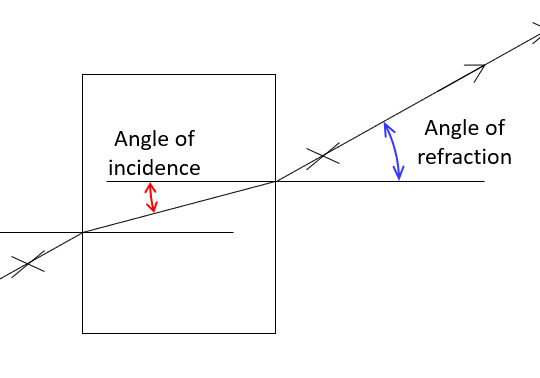
**Procedure**

1. Shine a ray of light into a long side of the glass block so it leaves out of the opposite side.



1. Measure the angle of incidence and the angle of refraction as the ray of light enters the block.
2. Measure the angle of incidence and the angle of refraction as the ray of light leaves the block.
3. Repeat the measurements for a good range of angles.

**Measurement details**



Light entering glass

Light leaving glass

**Results**

|  |  |  |  |
| --- | --- | --- | --- |
| Light entering glass | | Light leaving glass | |
| Angle of incidence | Angle of refraction | Angle of incidence | Angle of refraction |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |

**To answer**

1. When a ray of light enters glass, does it bend towards or away from the normal line?
2. What is the rule for the refraction of light leaving a glass block?
3. Is light refracted most when it enters or leaves the glass block?
4. What is the angle of incidence when there is no refraction?

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

|  |
| --- |
| **Response activity** |
| **Measuring 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 ray diagrams to show how light refracts at a boundary between transparent media.  Describe rules for the refraction of light at a boundary between transparent media. |
| Activity type: | Application and practice - practical |
| Key words: | Refract, refraction, incident ray, angle of incidence, normal, refracted ray, angle of refraction |

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

* Diagnostic question: Refracting rays
* Diagnostic question: Bending bananas

**What does the research say?**

A common strategy for teaching students about refraction is to demonstrate examples of refraction phenomena and to explain the observations using ray diagrams that show how light is bent by glass blocks. In this approach students may use a ray box to explore how light travels through a parallel sided glass block to understand the nature of refraction. They change the angles of incidence to establish: a change of direction only occurs at an interface; light travelling perpendicular to the interface is not refracted; and light bends towards the ‘normal’ when entering an optically more dense medium and vice versa (Davenport, 2021).

In a study of (n=213) Greek students age 14-15, who had previously studied refraction, Fyttas et al. (2013) found that about half thought that light continued in a straight line at a boundary between air and glass, because glass is transparent. Significant numbers thought wrongly that light was wholly reflected at a boundary or that it was refracted the wrong direction. When answering questions about refraction most did not consider a general rule for refraction.

**Ways to use this activity**

This practical activity gives students the opportunity to practise applying their understanding and to clarify their thinking through discussion. To support this, students should complete the practical 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 report their findings at end of the practical work 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*

Providing suitable recording sheets can help some students organise their observations so they can more easily focus on the science. 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. Some students may benefit from being challenged to plan and organise their own record keeping.

This investigation can be extended to observe the partial reflection at each surface.

Students could be encouraged to consider what sorts of angles of incidence produce the greatest refraction (larger ones).

It may be appropriate, with some groups, to introduce Snell’s law to describe the pattern between the angle of incidence and angle of refraction: sin(i) = sin(r).

**Equipment**

For each student/pair/group:

* Rectangular glass block
* Ray lamp and slit
* Power supply
* Ruler
* Protractor
* Large sheet of plain paper (A3)

**Technician notes**

This investigation requires a room with blinds that can be closed so the rays of light can be clearly seen. Total blackout is not necessary.

A collimating lens could be used with each ray lamp to ensure the rays do not spread out.

If the lower surface of the glass block is painted white, a light ray can be seen more clearly as it passes through the glass block.

Glass and Perspex (acrylic) blocks have approximately the same refractive index and either type can be used.

**Health and safety**

Power packs with damaged plugs or loose wires should not be used.

If it is possible, power packs should be limited to the working voltage of the bulbs used.

If filament bulbs are used, these get hot at operating temperatures and can cause burns.

Practical work should be carried out in accordance with local health and safety requirements, guidance from manufacturers and suppliers, and guidance available from CLEAPSS.

**Expected answers**

1. Light refracts towards the normal line when it enters glass (or any optically more dense medium).
2. Light refracts away from the normal line when it leaves glass (or enters any optically less dense medium).
3. The angles of incidence and refraction are reversed for each pair of measurements, with the light refracted the same amount but in the opposite directions.
4. There is no refraction if the angle of incidence is 0o (and light hits the surface at a right angle).

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Davenport, C. (2021). Waves. In de Winter, J. & Hardman, M. (eds.) *Teaching Secondary Physics.* 3rd ed. London: Hodder Education.

Fyttas, G., Komis, V. and Ravanis, K. (2013). Ninth grade students' mental representations of the refraction of light: didactic implications. *Mexican Journal of Physics,* 59**,** 133-139.