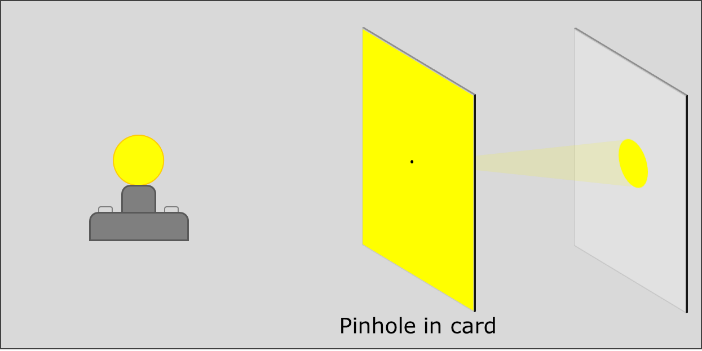
**Light through a hole**

A bright yellow lamp is placed in front of a pinhole.

There is a screen behind the hole.



Some students are discussing why they see a circle of light on the screen.

**Freddie:** Light from each part of the bulb goes through the pinhole at different angles.

**George:** Light squeezes through the pinhole and spreads out after it.

**Hannah:** When the hole is lit up the hole is like a lamp.

Light moves from it in all directions.

**Jessica:** Light from the top of the bulb moves in a straight line towards the bottom half of the screen.

**Isabella:** Most of the light from the lamp does not go through the pinhole.

**To answer**

1. Who is right about the light?
2. Who is wrong about the light?
   * What would you say to help them understand?

|  |  |
| --- | --- |
| Cards for  **Light through a hole** | **Freddie:** Light from each part of the bulb goes through the pinhole at different angles. |
| **George:** Light squeezes through the pinhole and spreads out after it. | **Hannah:** When the hole is lit up the hole is like a lamp.  Light moves from it in all directions. |
| **Isabella:** Most of the light from the lamp does not go through the pinhole. | **Jessica:** Light from the top of the bulb moves in a straight line towards the bottom half of the screen. |

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*Physics > Big idea PSL: Sound, light and waves > Topic PSL3: Making images > Key concept PSL3.1: The ray model of light to explain images*

|  |
| --- |
| **Diagnostic question** |
| **Light through a hole** |

**Overview**

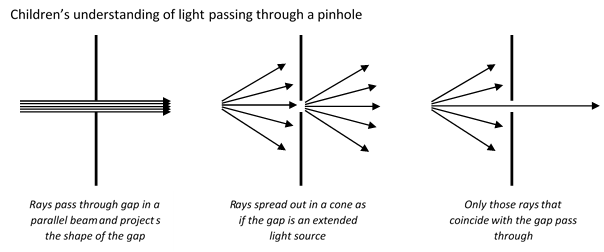
|  |  |
| --- | --- |
| Learning focus: | Only some light rays from each point of an illuminated object can pass through a pinhole, hitting a screen at distinct points to make an inverted image. |
| Observable learning outcome: | Describe how light rays pass through a pinhole. |
| Question type: | Talking heads |
| Key words: | Light ray, pinhole |

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

* Diagnostic question: Pinhole laser
* Diagnostic question: Pinhole lamp

**What does the research say?**

In order to explain image formation students need to understand that a light is emitted in all directions from each point on the source (Rice and Feher, 1987; Dedes and Kanstantinos, 2007; Galili and Hazan, 2000; Andreou and Raftopoulos, 2011). A suitable conceptual progression of how an image in a pinhole camera forms might start with the idea that rays *represent* the direction light travels in; use rays to show light moving from a luminous or illuminated object towards a pinhole; and finish with *one* ray from each point, out of infinitely many, passing through the pinhole and contributing to the formation of an image(Andreou and Raftopoulos, 2011).

Without the correct understanding of light emission from extended sources students make mistakes explaining how light passes through a pinhole. Galili and Hazan (2000) found over a third of students aged 14-16 thought light passed through a pinhole in a parallel beam. A further third thought that light spread out after the pinhole as if the hole was an extended source of light, and after instruction this *increased* to more than half.

**Ways to use this question**

This task is intended for discussion in pairs or small groups. It can be done as a pencil and paper exercise or projected onto a screen.

Students should read the statements and follow the instructions on either the worksheet or the PowerPoint. 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.

The bulb drawn in this response activity is deliberately uniform so the image on the screen is a circle of light rather than an inverted image of the bulb. The focus here is on how the rays of light pass through the pinhole, ideas about how an image is formed in a pinhole camera are developed later in the conceptual progression.

*Differentiation*

The quality of the discussions can be improved with a careful selection of groups; or by allocating specific roles to students in the 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**

Freddie, Isabella and Jessica are correct.

Light from each part of the bulb goes through the pinhole at different angles, with light from the top of the bulb moving in a straight line towards the bottom half of the screen and vice-versa. Most of the light from the lamp does not go through the pinhole, so the image will be quite dim.

George is wrong

Rice and Feher (1987) found that 14% of 9- to 13-year-olds drew pictures of light squeezing through a hole as George describes. To help George understand students can explain how laser beams can be seen to travel through the hole in straight lines. They might also explain that there is not a mechanism to explain how the hole can physically squeeze light.

Hannah is wrong

Rice and Feher (1987) found that 18% of 9- to 13-year-olds agree with Hannah and do not distinguish between a lamp and an illuminated hole. To help Hannah understand students can explain how each point on a lamp is glowing and emitting light in all directions, but the hole is lit up only from the light moving in straight lines from the lamp. Lasers can be used to show that the light from the lamp travels through the hole in straight lines and there is no mechanism to make the light physically change direction.

NB Diffraction effects as light passes through a pin hole are negligible in this context.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

Andreou, C. and Raftopoulos, A. (2011). Lessons from the history of the concept of the ray for teaching geometric optics. *Science and Education,* 20**,** 1007-1037.

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