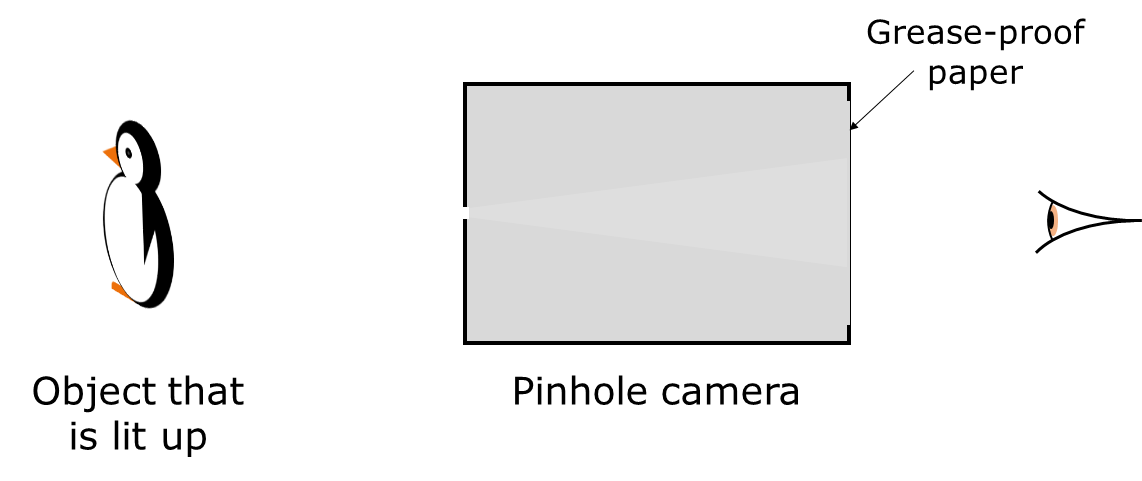
**Pinhole camera**

A pinhole camera is a box with a tiny hole in the front.

On the back is a piece of grease-proof paper.

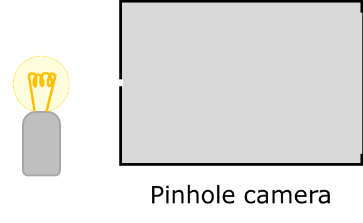
When there is an image, it is seen on the grease-proof paper.



**Apparatus and materials**

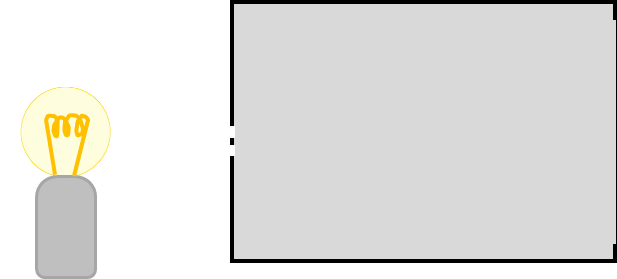
* Pinhole camera
* Optics pin (to make a hole)
* ****Carbon filament lamp (to look at)

**Procedure**

1. ****Make one pinhole in the front of the camera.
2. Point the camera at a carbon filament lamp.
3. Look at the image on the grease-proof paper.

* *Describe the shape and brightness of the image.*
* *State which way up the image is.*

**Pinhole camera – two pinholes**



**Predict**

What do you think you will see if there are two pinholes in the front of the camera?

**Explain**

Why do you think you will see this?

|  |
| --- |
| **Make a second pinhole next to the first one.**  **Look at the image.** |

**Observe**

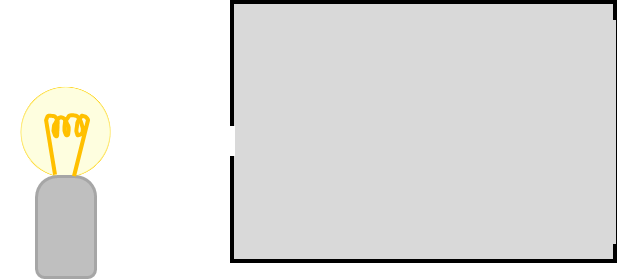
Describe what you see.

**Explain**

Were your prediction and explanation correct?

Try to improve your first explanation to explain what happens more clearly.

**Pinhole camera – one larger hole**



**Predict**

What do you think you will see one larger hole in the front of the camera?

**Explain**

Why do you think you will see this?

|  |
| --- |
| **Make the two pinholes into one larger hole.**  **Look at the image.** |

**Observe**

Describe what you see.

**Explain**

Were your prediction and explanation correct?

Try to improve your first explanation to explain what happens more clearly.

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

|  |
| --- |
| **Response activity** |
| **Pinhole camera** |

**Overview**

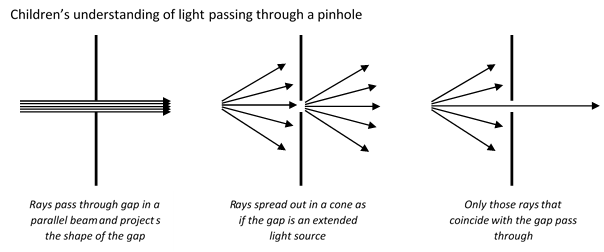
|  |  |
| --- | --- |
| Learning focus: | Only some light rays from each point of an illuminated object can pass through a pinhole, hitting a screen at distinct points to make an inverted image. |
| Observable learning outcome: | Explain how an image is formed on a screen behind a pinhole. |
| Activity type: | Predict, explain; observe, explain (PEOE) |
| Key words: | Light ray, pinhole, image |

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

* Diagnostic question: Pinhole penguin

**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 *a few* rays 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.

Students often think of an image as a physical replication of an object which can travel, remain still or turn as a whole. They may ascribe active powers to mirrors, lenses or pinholes to manipulate images in order to explain how they appear in a particular way on a screen (Galili and Hazan, 2000). In describing how light passes through a pinhole to form an image Rice and Feher (1987) found up to 20% of 9- to 13-year-olds ascribe such active power to the hole.

**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.

To begin, each group makes a pinhole camera with one pinhole and observes a carbon filament lamp.

They should then discuss what they think would be seen if a second pinhole is added. They should apply their scientific understanding, firstly to predict *what* they think will happen, and then to explain *why* they think they are going to be right. If students in any group cannot agree, you may be able to direct them with some careful questioning.

Students now carry out this part of the investigation and make their observations and be given the opportunity to change, or improve their explanation.

A good way to review your students’ thinking at this stage might be through a structured class discussion. You could ask several groups for their *explanations* and put these on the whiteboard. Then ask other groups to suggest which explanation is the most accurate and the most clearly expressed, and through careful questioning work up a clear ‘class explanation’.

Students now carry out the final part of the investigation, make their observations and change, or improve their explanation.

A second structured class discussion can be used to check understanding. A useful follow up is for individual students to then write down explanations for all their observations in their own words – without reference to the class explanation on the board (i.e. cover it up).

*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 a 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.

**Equipment**

For each student/pair/group:

* Pinhole camera
* Optics pin (to make a hole)
* Carbon filament lamp (to look at)

**Technician notes**

The bright filament inside a carbon filament lamp makes a clear image on the back of a pinhole camera. Other bulbs are not nearly as effective. To see the image clearly the light needs to be quite dark with lights out and blinds drawn. It is probably sufficient to set up five or six of these around the room for students to move to in order to make observations. Warning signs to indicate that the lamps get very hot are recommended.

Reusable cardboard pinhole cameras are available to buy. Alternatively make out of any small cardboard box that is approximately 15cm x 15cm x 15cm (exact dimensions are not important). Tin cans may also be used if the lid and bottom are removed to leave no sharp edges.

Cut a square hole about 3cm x 3cm out of the front of the camera. The back of the camera should be made from one sheet of grease-proof paper. Each lesson a small piece of thin black card can be stuck over the front opening. Students will make holes in this, so it needs to be replaced each time the cameras are used.

**Health and safety**

It can be tempting for students to *play* with optics pins. These need to be counted at the start and end of the lesson. For some classes it might be sensible to limit the number of pins by having one or two stations at which students can make their holes.

The carbon filament lamps get very hot and use mains electricity. It may be appropriate to attach warning signs.

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**

One pinhole

Sharp, dim inverted image of the carbon filament.

Two pinholes

Two sharp, dim and inverted images of the carbon filament. One image is displaced from the other.

Light moves along the rays from the top of the filament and pass through one of the pinholes to make a point of light towards the bottom of the screen. Light moves similarly along other light rays from other points on the filament to build up an inverted image on the screen. Light moves along other rays from each point on the filament through the second pinhole and make a second identical image a little displaced from the first.

One larger hole

One blurred, brighter inverted image of the carbon filament.

Light moves along lots of rays of light from each point on the filament through the hole. They form a bright spot on the screen that is spread out a little as lots of rays from the same point can pass through the hole, each at a slightly different angle. Light moving along rays from each point on the filament form bright spots on the screen that add together to form an inverted image. Because the spots overlap the image they make is blurred.

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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Dedes, C. and Kanstantinos, R. (2007). Teaching image formation by extended light sources: the use of a model derived from the history of science. *Research in Science Education,* 39**,** 57-73.

Galili, I. and Hazan, A. (2000). Learners' knowledge in optics: interpretation, structure and analysis. *International Journal of Science Education,* 22(1)**,** 57-88.

Rice, K. and Feher, E. (1987). Pinholes and images: childres's conceptions of light and vision. *Science Education,* 71(4)**,** 629-639.