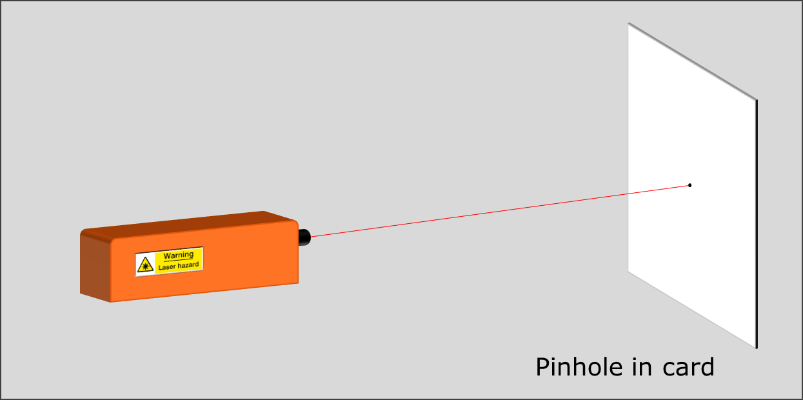
**Pinhole laser**

Jay’s teacher is shining a laser beam at a very small hole.

His teacher sprays the laser beam with a fine mist of water so it can be seen.



Which of these diagrams show how laser beams can pass through the hole?

For each statement, tick (✓) **one** column to show what you think*.*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | | I am **sure** this is right | I think this is right | I think this is wrong | I am **sure** this is wrong |
| **A** |  |  |  |  |  |
| **B** |  |  |  |  |  |
| **C** |  |  |  |  |  |

*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** |
| **Pinhole laser** |

**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: | Confidence grid |
| Key words: | Light ray, pinhole |

**What does the research say?**

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.

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).

This question investigates students’ understanding of light, represented by rays, passes through a pinhole.

**Ways to use this question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use an electronic ‘voting system’ or mini white boards and the PowerPoint presentation.

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs.

*Differentiation*

You may choose to read the questions to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Equipment**

For the class (optional):

* Red laser and green laser
* Matt card with a small hole in the centre
* Matt card with no hole (as a non-reflective target to place a distance behind the pinhole)
* Spray bottle of water to produce a fine mist
* Drying cloth
* Warning sign(s)

**Technician notes**

Each laser needs to be set up so that it is pointing through a small hole in the card at a matt screen, away from all students and with no reflective objects close to its path. If a laser pointer is used it should be clamped so that it does not move.

**Health and safety**

**Full details of health and safety procedures relating to lasers need to be fully understood before carrying out experiments with lasers.**

Water should not be sprayed close to the laser itself and wet floors should be dried immediately.

If there is any chance that someone could enter the room and walk into the beam, then warning signs must be displayed outside the room.

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**

All three of the diagrams are correct.

**How to respond - what next?**

It is usually assumed that what happens in these examples is obvious to all students. However, Rice and Feher (1987) found that 18% of 9- to 13-year-olds drew diagrams of beams of light spreading out as they pass through a small hole. In the same study 14% of students drew diagrams that showed rays of light (as in part C above) *squeezing* through the hole and spreading out again on the other side without crossing over each other. In Rice and Feher’s study students were asked about light from an extended light source, and it is anticipated that diagrams in this question showing laser beams will reduce the prevalence of these misunderstandings.

If students have misunderstandings about how single rays of light pass through a small hole, it can be helpful to demonstrate what happens using a laser. Spraying the laser beam with a fine water spray will make clear the path of light that the ray represents. Two lasers may be set up (ideally of two distinct colours) to show *example C* with two rays.

Laser beams have been used in this question to illustrate the movement of light represented by a single ray passing through a pinhole. The next step is to consider multiple rays of light from each point on an extended light source incident on a pinhole. The BEST diagnostic question: *Pinhole lamp* can be used to investigate students’ understanding of how rays of light from an extended light source either pass straight through a pinhole or are blocked by card.

The following BEST ‘response activity’ could be used to facilitate paired or small group discussions about how light passes through a pinhole, which encourage social construction of new ideas through dialogue:

* Response activity: Light through a hole

**Acknowledgments**

Developed by Peter Fairhurst (UYSEG).

Images: Peter Fairhurst (UYSEG).

**References**

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