Infinity Derivation

Teacher's Guide

Topic:

Reflection and Mirrors

The following information is provided to the student:

Question:
What mathematical equation could be written to describe the image distances resulting from a set of parallel plane mirrors?

Purpose:
To use geometry and mathematical reasoning in order to determine the mathematical equation which could predict the location of an image formed by a set of parallel plane mirrors.

A complete lab write-up includes a Title, a Purpose, a Data section, a Conclusion and a Discussion of Results. (This lab is unique in that there are neither measurements nor observations; knowledge is generated using mathematical/logical thought.) The Data section should include the provided diagram; the diagram shows an object positioned between two mirrors separated by a distance $\mathbf{d}_{separation}$; The object is a distance d_{left} from the left-most mirror and d_{right} from the right-most mirror. Primary, secondary, tertiary, quaternary, … images to the left and the right of the two mirrors should be located and labeled. Distances to the mirrors should be labeled as well. Once repeated for several images (a minimum of five), an effort should be made to generate a mathematical equation which predicts the image distance ($\mathbf{d}_{image\ n}$) for the $\mathbf{n}^{th}$ image to the right of the right-most mirror. Unsuccessful (perhaps several) and successful equations should be listed in the Data section; that is, document the process (scribbles, cross-outs, and start-overs due to failed attempts are more scientific than clean, sterile and pristine reports which fail to capture the analysis process). The Discussion of Results section should demonstrate how the derived equation effectively predicts the image distances for the first five images to the right of the right-most mirror.

Materials Required:

None

Description of Procedure:

Students construct a diagram of two mirrors with a separation distance of $d_{separation}$. A bold dot (representing an object) is placed between the two mirrors, located a distance of d_{left} from the left-most mirror and d_{right} from the right-most mirror. Some numbers are assigned to the three variables; for instance, d_{right} = 5 cm, d_{left} = 3 cm and $d_{separation}$= 8 cm. Using the principle that $d_{object} = d_{image}$,, students begin to determine the image location for the numerous images to the left and to the right of the arrangement of mirrors. The distance to the nearest mirror is labeled. Once several images and their corresponding distance is determined, students look for a pattern in the numbers in an effort to determine the equation for predicting the distance between the right-most mirror and the n^{th} image to the right of the rightmost mirror.

Alternative Materials and Procedure:

Alternative materials and procedures are not recommended.

The Laboratory

Safety Concern:

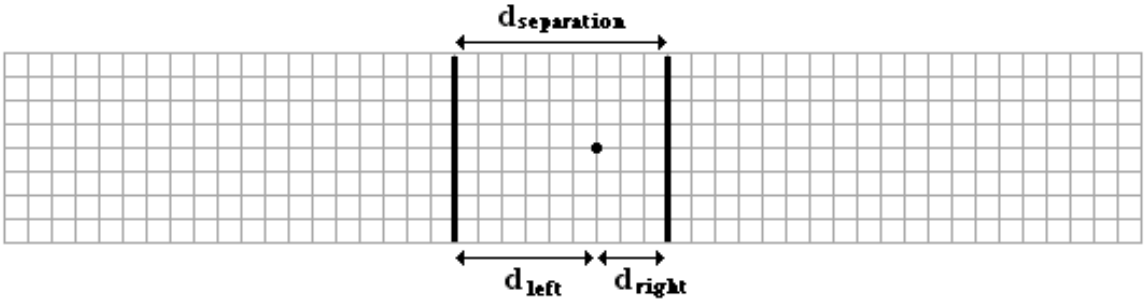
There is always a higher than usual level of risk associated with working in a science lab. Teachers should be aware of this and take the necessary precautions to insure that the working environment is as safe as possible. Student *horseplay* and off-task behaviors should not be tolerated.

Suggestions, Precautions, Notes:

1. This is a difficult activity which should only be performed with your most able students. The generation of the data, the analysis of the data, the determination of a numerical pattern, and the development of a suitable equation are all challenging tasks.
2. Emphasize to students that the focus is upon the images located to the right of the right-most mirror and the distance between those images and the right-most mirror.
3. In the data collection phase of this lab, students may want to use actual numbers in place of the variables d_{right} , d_{left} , and d_{right}. Once the pattern has been determined, they can express the equation in terms of the variables d_{right} , d_{left} , and d_{right}. Many students may find it necessary to write two equations - one for the case of **n** being odd and the other for the case of **n** being even.

Auxiliary Materials:

The following page is provided to the student for completion and inclusion in the Data section of their lab notebook.



Scoring Rubric:

RM7.	**Improving Your Image Lab**	**Score**
____	Included, labeled and organized all parts of the lab report.	
____	Data section includes a table of **Θ** - **N** data; column headings and angle units are stated. Includes a graph of **N** vs. **Θ**; axes are labeled. Logical progression from data to conclusion is documented; the progression may involve linear regression analysis, power regression analysis, or a trial-and-error process of equation-writing. The process of linking the data to the equation is documented and *explained*; cross-outs of and scribbles on top of wrong paths and failed attempts are wholly scientific.	____/____
____	Conclusion states the equation which relates the number of images (**N**) to the angle between the mirrors (**Θ**).	

Connections to The Physics Classroom Tutorial:

The following reading is a suitable accompaniment to this lab:

http://www.physicsclassroom.com/Class/refln/u13l2f.cfm

Connections to Minds on Physics Internet Modules:

There are no sublevels of Minds On Physics pertaining to the topic of multiple mirror systems.