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Course Name: Physics
Unit Title: Pinhole Projection

Date: January 27-28, 2000
Grade Level: HS Juniors and Seniors
Concept: Image Formation

Goal: The goal of this four-class-period lesson is to get students to use inquiry to learn about the various factors that account for image formation. (Note: As collect students we will move much faster, completing two exercise in each of two parts.)

Guiding Questions: How and why are images formed through pinhole projection? What is the relationship between and among distances of image and object from the pinhole, and the image and object heights?

Objectives: At the conclusion of this exercise the students will have demonstrated the ability to:

1. State which factors affect image formation, and which do not.
2. Use scientific instruments to determine the relationships between image height (h_i) and pertinent factors such as image-to-pinhole distance (d_i), object-to-pinhole distance (d_o), and object height (h_o).
3. State the nature of the relationship between the various pertinent factors and image height.
4. Derive the algebraic relationship between image height and other pertinent factors.
5. Work numeric problems using the derived relationship.
6. Explain how the algebraic relationship was derived.
7. Use basic formulae to calculate magnifications of different combinations of d_i, d_o, and h_o.
8. Explain the basic nature of scientific research using pinhole projection as an example.

Content:

I. Relationships – Image height is affected:
   A. Directly with image height
   B. Directly with image distance from pinhole
   C. Inversely with object distance from pinhole
   D. Magnification $h_i/h_o = d_i/d_o$
   E. Magnification is < 1 if $d_i < d_o$
   F. Magnification is > 1 if $d_i > d_o$

II. Image size is not affected by the following parameters:
   A. Pinhole size
   B. Pinhole number

III. Traits of pinhole projections:
   A. Image is flipped top to bottom
   B. Image is flipped left to right
   C. The 180 rotation is known as inversion
   D. Produced by straight-line propagation of light.

Lesson Overview: This activity incorporates one learning cycle over the course of four days. Students will experiment in the first phase of a learning cycle (observation) in an effort to find meaningful conceptual relationships. They will then test measurable relationships collecting appropriate experimental data and graphing it (generalization). Once the relationship between image height and pertinent factors is identified, students will use the relationship to make various predications (application).

Procedure: Because this is an inquiry lesson, questions will guide the discussion throughout. Students will direct the discussion and class activities by their responses to questions and suggestions for experiments. Here are the basic questions that will be followed throughout the lesson.

<u>Day 1:</u>

1) Class demonstration of pinhole projection with three lamps; using two index cards for each student. What do you see? Are they all the same? What are the variables? Give variables labels (e.g., d_i, d_o, h_i, h_o). Are there other pertinent variables in relation to image height?

2) CONCEPTUAL MODELS: Examine projection box: find every conceivable relationship, white board relationships using words to describe. Whiteboard results. DO NOT HAND OUT RULERS.

Day 2:

3) DIAGRAMMATIC MODELS: Resolve problem with source being smaller than pinhole if students find it. Think about how image creation works. Think diagrammatically. Whiteboard and present hypothesis.

4) Assign worksheet two.

Day 3:

5) Identify those relationships worth investigating.

6) GRAPHICAL AND ALGEBRAIC MODELS: Have students quantify relationships: collect data, create graphical representation of data, create algebraic representation of data, and identify constants with variables whose quantity is known. Whiteboard and present findings.

Day 4:

7) Have students apply mathematical models to calculate magnification, etc.

8) Have students experimentally verify their calculations.

Materials:

Pinhole projection boxes	Three lamps on ring stand	Ruler
Extra wax paper	Two index cards per student	Meter stick
Extra tin foil	One paper clip for each student	Masking tape
Worksheets	White boards	Dry erase markers