angle θ = 0 for the motion makes nonsense of the calculation. The blackboard eraser is now placed on the edge of a table and pushed off with essentially zero horizontal velocity. The aim is to convince the students that the time taken for the eraser to hit the floor is independent of the horizontal velocity. Thus we bring out the essential point of projectile motion: the motion in the horizontal x direction is described by

$$x = u_x t \tag{3}$$

which is independent of the y motion

$$y = u_y t + a_y t^2/2 \tag{4}$$

Realizing this, it is easy to solve Eq. (4) for t and substitute this into Eq. (3).

Should these simple demonstrations fail, you will have to resort to using the blackboard eraser to clean the board and attempt to explain everything using diagrams and equations.

Reference

1. U. Haber-Schaim and J.H. Dodge, "There's more to it than friction," *Phys. Teach.* 29, 56 (1991).

Determining Plane Mirror Image Distance from Eye Charts

David R. Lapp

Tamalpais High School, Mill Valley, CA 94941

Most students find it very difficult to accept the fact that the image produced by a plane mirror is actually behind the mirror at the same distance the object is in front of the mirror. It takes an even longer time for them to truly "believe" it. Many techniques have been used to convince students of this counterintuitive idea. One method that I have used for a few years seems to have remarkable success.

I have a volunteer student stand in front of a plane mirror with a replicated standard eye chart (see Fig. 1 on the following page) taped to its surface. In this replicated eye chart I have made the letters in the third line half the size of the letters in the first line, the letters in the fourth line half the size of the letters of the second line, and so on. The student is moved back to a point where she can barely recognize the letters in one of the lower lines (I have her move to a position where she makes one or two mistakes in reading the line so that the limit of resolution is truly reached). At the same time she holds an eye chart, directly below her eyes, facing into the mirror. This eye chart is identical to the one taped to the mirror except that the characters are reversed so that their reflected image can be clearly read (see Fig. 2 on the following page).

Before the demonstration I'll ask students where they believe the image to be. Most believe that the image is on the surface of the mirror and refuse the notion that the image could be behind the mirror, presumably because the mirror's reflecting surface is opaque and light from the back side is unable to reach the eyes of the observer. I discuss the eye chart demonstration with them and ask which line in the reflected eye chart should be just readable. Most say that the same line as the line on the chart taped to the mirror should be just readable. They also agree that if the image is in back of the mirror then the observer would only be able to distinguish letters in one of the larger lines of the reverse eye chart (and conversely, if the image is in front of the mirror, one of the smaller lines in the reverse eye chart should be readable).

During the demonstration, the observer strains but is always able to just read the line in the reflected image that is exactly two lines up from the one she can read in the taped eye chart. This means she can distinguish only those reflected characters that are twice the height of the objects. One or more students invariably conclude that the image produced by a plane mirror is not only behind the mirror, but the same distance behind it as the object is in front of it. This, of course, can be verified by having the volunteer student read from an eye chart identical to the eye chart taped to the mirror and held at double the distance from the volunteer student as she is from the mirror.

This very effective demonstration is both qualitative and quantitative. In addition, it is very easy for students to understand and inexpensive enough for even the smallest budgets. When my students are later asked by their nonphysics peers to explain the seeming impossibility of an image being behind a mirror, they readily choose this demonstration to use for their explanation.

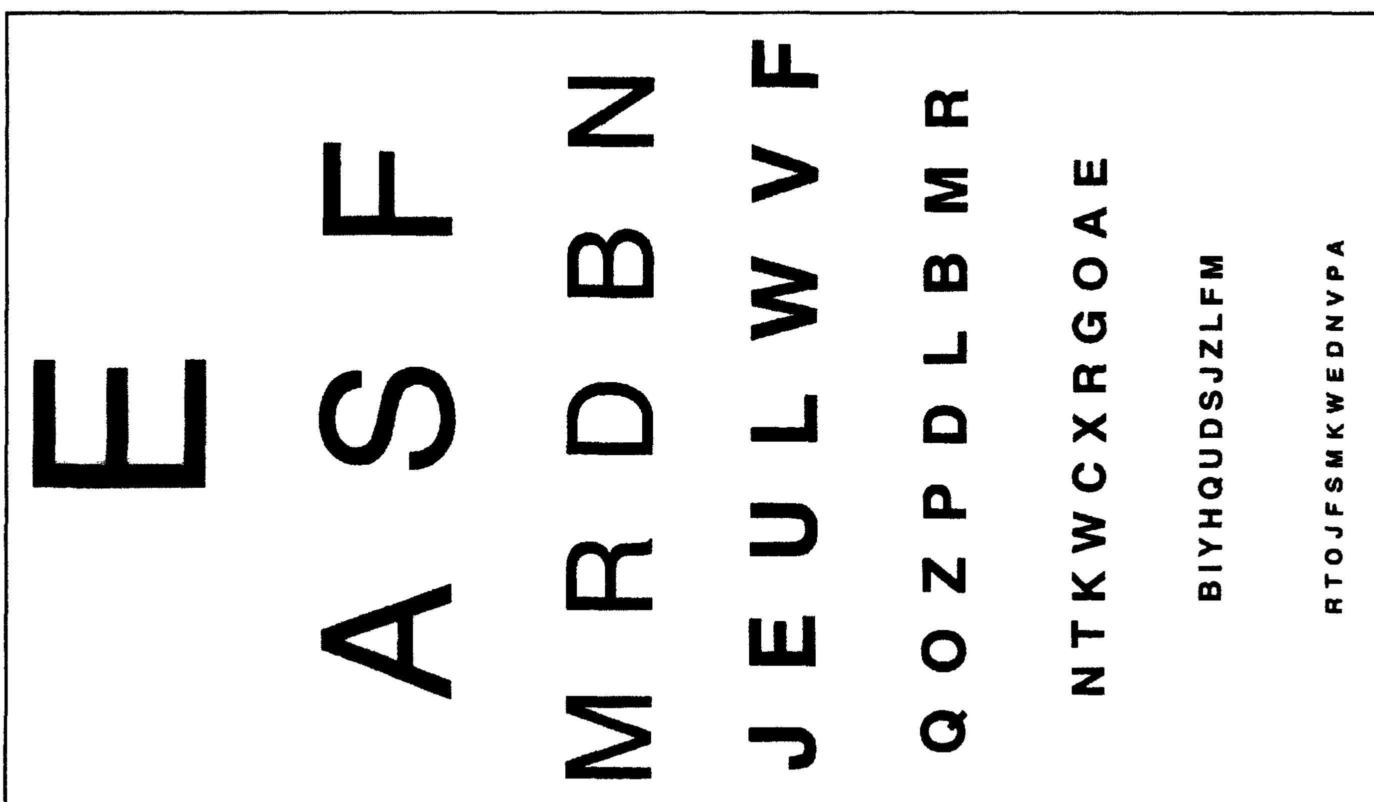

Fig. 1. Standard eye chart.

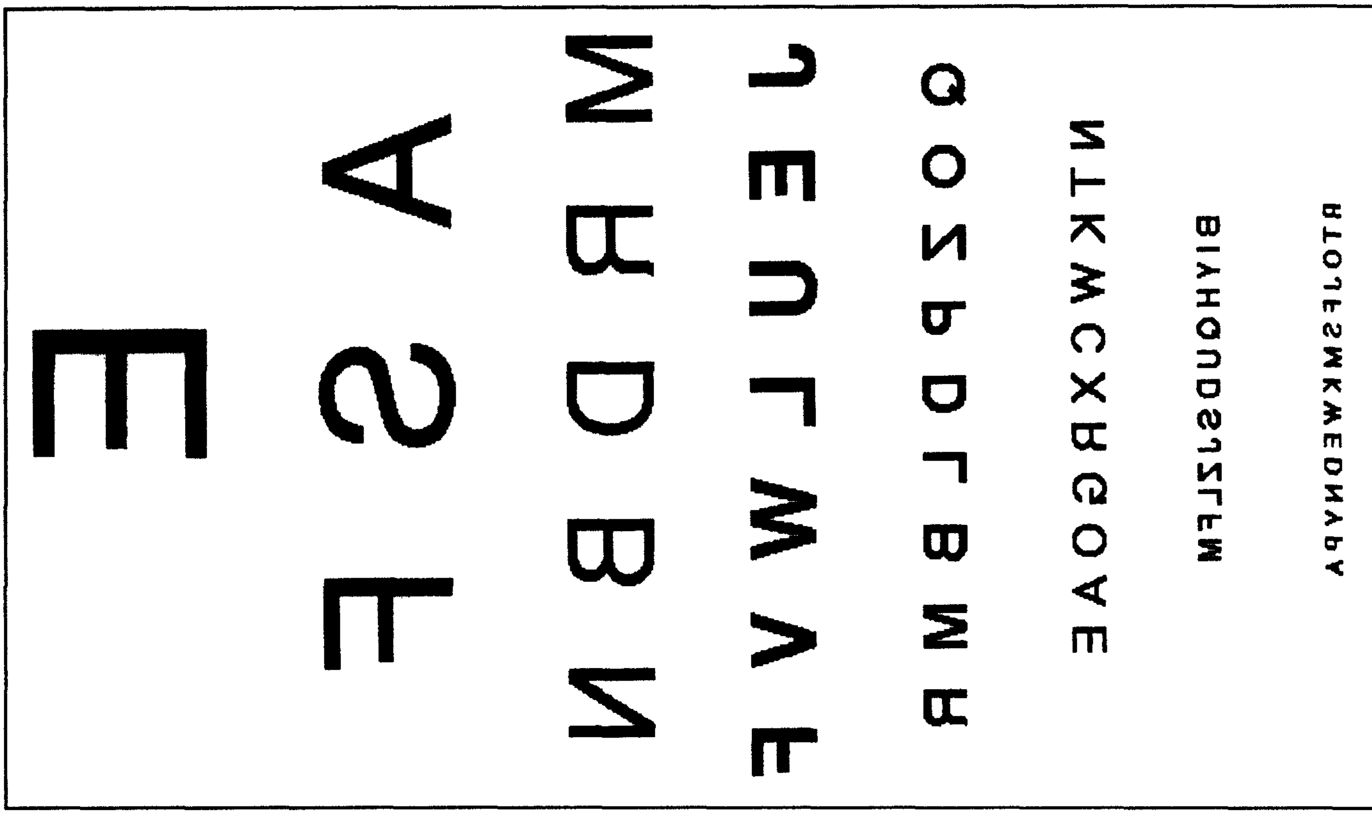
Fig. 2. Reversed standard eye chart.