Light Touch

Math Isn't Just Numbers Anymore

Today is a glorious time to be a mathematics teacher. The new national standards demand connections, not only between topics in mathematics but between mathematics and the real world.[1] Having taught both mathematics and physics for nearly two decades, I am having the time of my life incorporating concepts from one course into the other. Nationwide, mathematics teachers are scrounging around looking for real life applications to enhance their courses and make mathematics come alive for their students. This is a challenge for teachers who have not ventured far outside of their curricula before, and they could use the help of OSA members.

One way that individuals or local sections might help these educators is to share application ideas and expertise. For example, recently a parent came to my class to share how she collects and measures samples of aluminum for quality control. The next thing I knew, my algebra class was measuring aluminum samples and graphing the results. Talking is good, but what math teachers need are hands-on projects that allow math application at their students' level.

I found one such idea in the OSA Optics Discovery Kit.[2] I confess that the kit was not originally designed for this use, but it certainly was a handy way to let the students discover the value of the mathematics they had learned. I encourage you to share the following idea with your favorite mathematics teachers. Perhaps it will give you the lesson plan you need to visit a math classroom.

This plan was designed for students in math analysis or pre-calculus while studying rational functions, but can be used with any group in second-year algebra or beyond. The students work with the Optics Classroom Kit or in groups of three or four with one individual Optics Kit per group. Additional materials needed for each group are two spring-type clothespins, one meterstick, one index card, and a single light source. I borrowed the old physics technique of candles for my light sources. The students love the romantic notion of mathematics by candlelight, and the practical side is that math classrooms typically do not have enough electrical outlets. Younger students should probably not use open flames, however.

The only advance introduction necessary is to give the students a clear definition of real and virtual image types. The rest they can discover. The activity only takes one class period (about 50 minutes); teachers love that. Most students can submit their work within that time and others can complete the graphs overnight.

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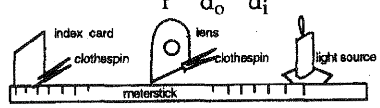
Rational Functions Worksheet

name ____________________

Lens Formula: $\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$



f=focal length
d_o=object distance
d_i=image distance

1. Move the light source to three different positions, each time recording the object distance and the image distance, both measured from the lens.

2. Calculate f, using the lens formula, for all three trials and average.

	d_o	d_i	calculated f
1			
2			
3			
		average f	

3. Experiment and predict: When the object distance approaches infinity, where will the image be located? ____________________

4. Focus an image of a very distant object on your screen (preferably an object you can see outside your classroom window).

5. Record this image distance as your accepted f= ______________ .

6. Compare the accepted f to the average experimental f above.

$$\text{Relative error} = \frac{\text{experimental f} - \text{accepted f}}{\text{accepted f}} \times 100\% = \_\_\_\_\_\_$$

7. Using the approximate f (to nearest two digits) and the lens equation, let d_i=y and d_o=x. Solve for y. Then graph f(x).

8. Label regions of the graph with meanings in type and size of image. Explain what happens at asymptotes.

9. Where is the image size the same as the object size? (d_o=d_i) Label this on the graph.

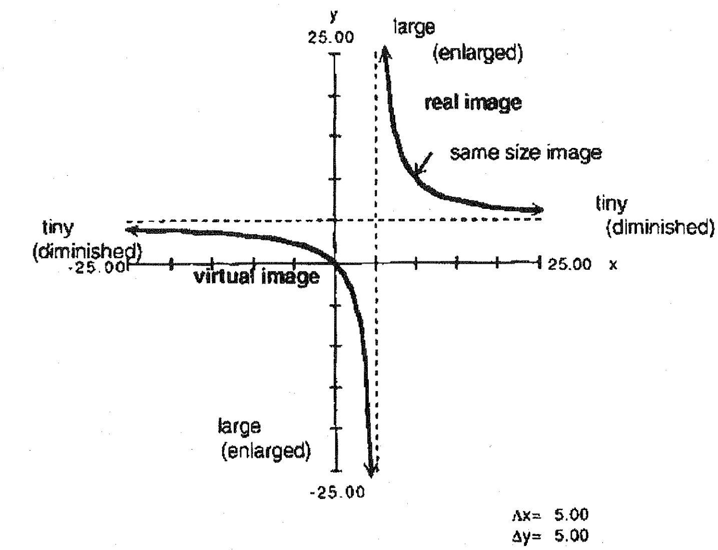
Definitions :
Real—images that are formed by actual beams; can be projected onto a screen; most distinguishing feature: inverted.
Virtual—images that appear to be formed; cannot be projected; most distinguishing feature: upright.

CONCLUSIONS

There is a predictable excitement near the end of this activity as students realize their graphs have meaning. Graphs and mathematics can predict outcomes in the real world. A discussion can follow about uses of lenses and image types. Further, if these graphs of rational functions have meaning, maybe all of the others do as well. The idea of a function becomes real, not virtual.

REFERENCES

1. F.J. Crosswhite, "National Standards: A New Dimension in Professional Leadership," *School Science and Mathematics*, **90:6**, 1990, 454-465.
2. Optical Society of America, *Official Optics Discovery Kit Student Guide*, Experiment #1—Lenses, 1990, 2-5.



SOLUTION USING LENS A: $F(X) = \frac{5X}{X-5}$ NOT SYMMETRIC TO Y-AXIS OR ORIGIN. POINT OF SINGULARITY = 5. LIMIT = 5. CROSSES Y-AXIS ONLY AT 0. CROSSES X-AXIS ONLY AT 0.