Light at a Distance

Materials: Light Sensor, Lamps with incandescent light bulbs, Fathom

Groups: Teachers need to be in groups of 3-4. Roles include: Person to hold light sensor and walk away from the source, person to set up and turn on experiment in Fathom, and recorder

Mathematical goals:

- Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.
  - a. Fit a function to the data; use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear, quadratic, and exponential models. (S-ID.6.)
- Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

d. Graph rational functions, identifying zeros and asymptotes when suitable factorizations are available, and showing end behavior. (F-IF.7.)

Technological goals:

- Teachers will be able to set up an experiment in Fathom using the light sensor
- Teachers will be able to create a table and graph of their data
- Teacher will be able to plot a function to model their data

Lesson Outline:

Background: When riding in a car at night you might have noticed the lights of an oncoming car seem dim at first but rapidly get brighter and brighter. This is because the light spreads out as it moves away from the source. As a result, light intensity decreases as the distance from a typical light source increases. What is the relationship between distance and the intensity for a simple light bulb?

In this activity you will explore this concept using a motion detector and Fathom, then model the data mathematically.

Make Predictions and Conjectures:

Discuss with your group what you think will happen. What type of model do you think will model light intensity as distance from the source decreases?

Set up the experiment in Fathom.

1) Open a new Fathom Window
2) Plug in the Light Sensor using the GoLink! Cable into your computers USB drive
3) Go to the icon "Meter" at the top of the window
4) Light Sensor should be at the top, choose it (If Light Sensor isn't at the top restart Fathom and try again. Sometimes it's a bit finicky)
5) Create a new collection
6) Drag plug into this collection (Inspector window should open)
7) Create a table and graph with the attributes time and luminance.
8) Design the experiment to be 20 cases per sec for 1.5 seconds (you may choose to change this, but these are good starting values)
9) Run your experiments

Experiment: Hold the light sensor about 10 cm from the light bulb. Move the sensor away from the bulb at a constant rate and watch the displayed intensity values on your Fathom graph.

1) What does your graph look like?
2) Why was it important to move the graph away at a constant rate?
3) How are distance and time related in this experiment?
4) One model for light intensity hold that the intensity is proportional to the inverse square of the distance from a point light source; that is, a graph would be of the form $y = \frac{C}{x^2}$, where *C* is an adjustable parameter. Use sliders and plot a formula to see if your data follows this model.
5) Another model that can be used to model the data might be the general power law of $y = ax^b$. This may provide a better fit than the inverse-square function, especially if the light source is not small or if there are reflections from walls or other surfaces. Try to model your data with a function of this form. Is it a better fit? Mathematically what's the difference between this function and the inverse square function?
6) How would using a brighter light source affect the parameters *a, b,* and *C* in the two models?

Extension:

1) Suppose that your patio is illuminated by an overhead light fixture with two bulbs. You decide to save on electricity by removing one of the bulbs. If the light is currently mounted 5m off the ground, to what height should the light fixture be moved in order to retain the same amount of light on the patio with one bulb? Does your answer depend on the model you use?
2) In this experiment we've been using incandescent light bulbs. Would CFL or an LED light bulb behave in the same way? Perform the experiments to test your prediction.