Laser Light(Inverse Square Law)

Amount of time for this lesson = _55____ minutes – Grades 10, 11, 12

1. Standards and Safety and Materials:

A. Standards –Common Core Math Standards 9-12

CCSS.Math.Content.HSA.CED.A.1
Create equations and inequalities in one variable and use them to solve problems. *Include equations arising from linear and quadratic functions, and simple rational and exponential functions*.

CCSS.Math.Content.HSA.CED.A.2
Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

CCSS.Math.Content.HSA.CED.A.4
Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. *For example, rearrange Ohm's law V = IR to highlight resistance R*.

CCSS.Math.Content.HSA.REI.B.3
Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

B. Safety Concerns: Students need to be instructed of the damage to vision that a laser can cause.

C. Materials: Laser Pointers (the cheap laser pointers from the dollar store work well)
Diffraction grating – inexpensive sources are fireworks glasses or rainbow glasses.
Extra batteries for laser pointers

2. Objectives:
Students will be able to **create** a scatter plot of data and **derive** an equation (model) to fit the data.
Students will be able to use their equations to **predict** distance vs area.

3. Connections, Misconceptions, and Crosscutting Concepts:
A. Real world connections: Physicist, Astronomer, Mathematician, Engineer
B. Student connections: Relationship between distance and brightness of light
The student data will have a pattern that can be modeled
C. Misconceptions: There is a possibility for students to think the diffraction grating causes the laser light to spread out and that this is not a fundamental property of light.
D. Crosscutting Concepts: Patterns, Scale-Proportion-Quantity, and System Models
E. Background: The intensity, *E*, of a light source is inversely proportional to the square of the distance from the light source. Gravity and magnetism are also inversely proportional to the square of the distance. Rainbow glasses are made up of a film with many small slits, which act as a diffraction grating. When a flashlight is shone through the diffraction grating, a rainbow is produced. When laser light is shone through the diffraction grating, the laser dots are shown in a rectangular or square grid pattern. I have found that it is much easier for students to measure the rectangular grid pattern from the lasers instead of the traditional inverse square law lab where students draw a circle around the light from a flashlight on graph paper.

4. Catch/*Engagement*: Darken the room so the flashlight is visible on a whiteboard. Stand 1m away from wall and slowly back up. You may wish to stop at a few intervals and ask the students what is happening to the light as the flashlight gets farther away from the wall.

5. Pre-test: How does light travel? What happens to light as it travels?

6. Activity/*Exploration*: See student handout. The activity is similar to the *engagement* but with a laser. Students will measure the distance of dispersion at different distances. Then students will create a scatter plot of their data and make a model/equation for this data.

7. Review/Essential Questions/*Explanation*: What is relationship between area and distance in relation to light dispersion?
What are major component of a scatter plot?
What information do you need to derive an equation or model?

8. Assessments (Post-test)/*Evaluation*:
A. Formative: Oral questions regarding essential questions.
B. Post-test: Same as pre-test.
C. Summative: Students will turn in handout with their graphs and models of data.
D. Explain how the data will inform tomorrow's teaching: If class average is below 80%, I will review data graphs and models.

9. Timeline:

A. Catch	2 min
B. Pre-test	3 min
C. Activity	42 min
D. Review and Post-test	8 min

10. Enrichment/*Elaboration*: Students who finish early can then compare data of colored lasers by analyzing the graphs and models to explain why different colors disperse at different rates.

Student Handout

Inverse Square Law Lab

Name:_________________________________ Date:___________________

Pre-lab 1: Watch as your teacher does a demonstration with a flashlight, laser pointer and diffraction grating. Write your responses in the space provided.

What happens to the light as the light source gets farther away from the wall?	
Flashlight	Laser Pointer

Pre-lab 2: What is the relationship between distance and brightness of light?

Pre-lab 3: Imagine your teacher is an alien from another planet and the wall is the earth. This alien can travel throughout the galaxy and get farther away from Earth. What happens to the alien's signal as it gets farther away from Earth?

Safety Concerns:

✓Never shine the laser pointer in your eyes or anyone else's eyes. Take care in keeping the laser pointer away from your face and everyone else's face.

Please write your initials in the space provided to indicate that you have read and understand this safety concern: _____________

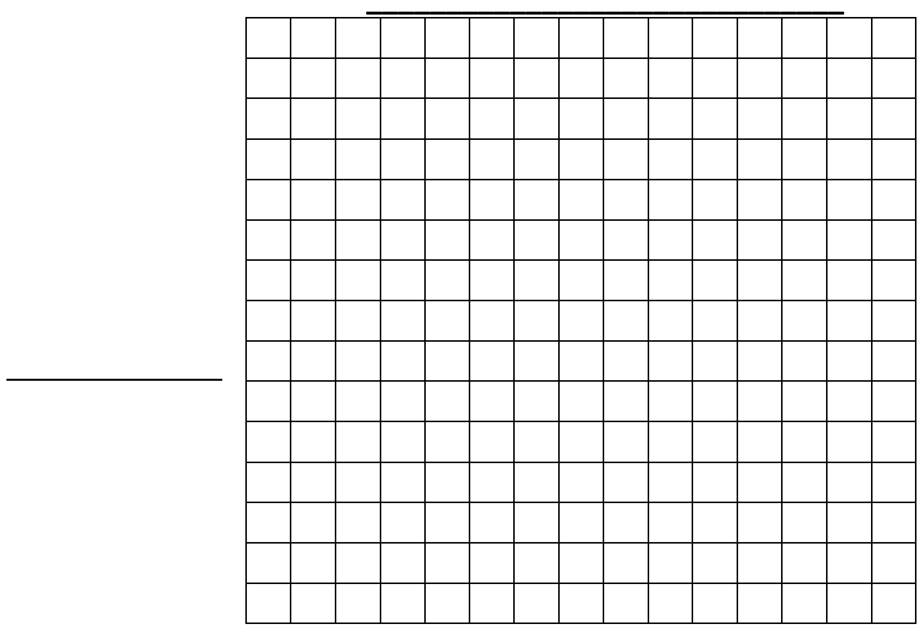
Procedure:

1. Hold the laser pointer to aim at the wall or whiteboard as the teacher did.
2. Have one partner hold the fireworks glasses in front of the laser as the teacher did.
3. Move the laser pointer so it is 0.25m (d = 0.25m) away from a screen, wall, or marker board.
4. Observe the pattern the laser light makes on the screen.
5. Measure the length and width of the square (some glasses will produce a square, others will produce a rectangle). One of the four points of the square must be the original laser light. Record the length of the sides in the table below and calculate the area (A) in m^2.

6. Repeat the procedure for each of the distances listed in the table.

Distance (m)	Length (m)	Width (m)	Area (m^2)
0.25m			
0.50m			
0.75m			
1.00m			
1.25m			
1.50m			
2.00m			

7. Plot a graph of the Area versus Distance on the grid below:



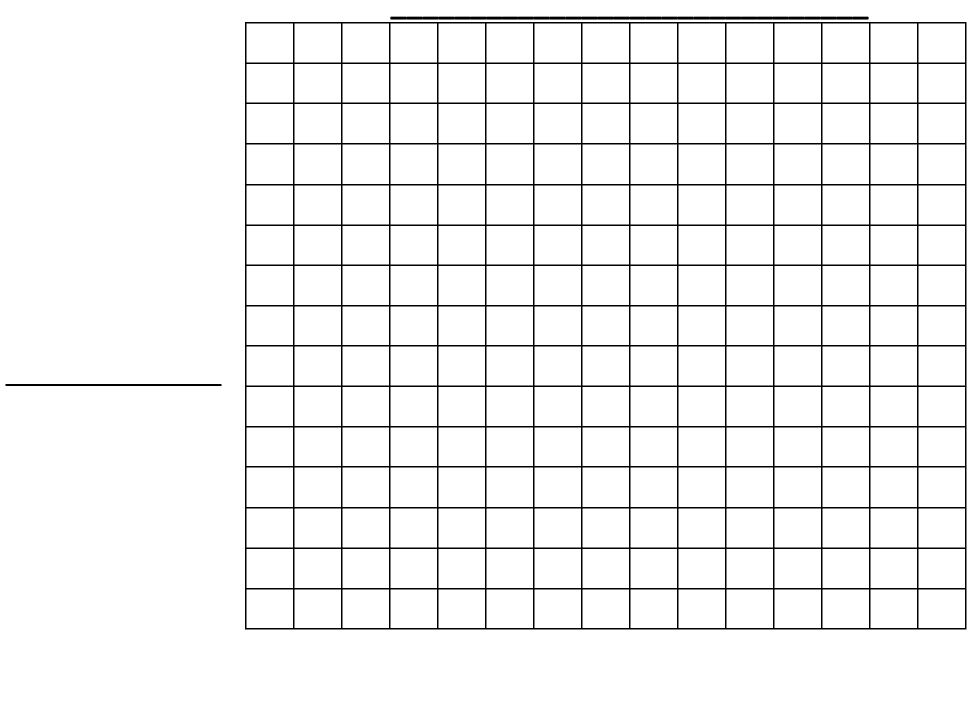
8. Decide if it is linear, quadratic, exponential, or some other function.

9. Now, find the explicit model for the data and graph.

10. Now, copy your information from previous table but notice there is now a distance squared column.

Distance (m)	Distance^2 (m)	Length (m)	Width (m)	Area (m^2)
0.25m				
0.50m				
0.75m				
1.00m				
1.25m				
1.50m				
2.00m				

11. Now, plot a graph of the Area versus Distance Squared on the grid below:



12. Decide if it is linear, quadratic, exponential, or some other function.

13. Now, find the explicit model for the data and graph.

14. In this lab, the area of the rectangle produced by the laser points represents the area that would be illuminated by a light source (such as a flashlight). What is the relationship between the illuminated area and the distance away from the screen?

15. Based on your data, graph, and model before, predict the area of the rectangle produced by the laser points when the laser is 5m away from the screen. Be sure to show your work.

SETI, the Search for ExtraTerrestrial Intelligence, is searching for radio signals originating from space that may have been sent by intelligent life. Initially, the searches looked for signals from nearby stars. Searches are now looking for sources from farther out into the galaxy.

One of the many challenges for SETI is detecting such a weak signal and trying to separate the weak signal out from all the background radio noise. Another challenge is that the signal must be repeated. Many signals have been received that may have been sent by intelligent life, but none of these signals have been received more than once.

16. How many times *fainter* would a signal be from a source that is 5 lightyears[1] (ly) away compared to a source that was emitted from a planet orbiting a star that is 1 ly away?

17. A signal is received from a star that is 50 ly away. What is the strength of the signal received on earth compared to the original signal?

[1] A light year is a unit of astronomical distance. It is the distance light travels in one year. A light year is equal to almost 6 trillion miles (5.88 trillion miles to be exact) or 10 trillion kilometers!