Lesson Title	Parallel Lines with Lasers and Mirrors
Length of Lesson	1 50-minute lesson
Created By	Sean Owens
Subject	Mathematics, Geometry
Grade Level	9^{th} – 12^{th}
State Standards	9^{th} - 12^{th} Pre-Algebra: 4 a; 4 c Transition to Algebra: 4 a; 5 a Algebra 1: 3 a Geometry: 2 a
DOK Level	DOK 1 – Pre-Algebra DOK 2 – Pre-Algebra, Transition to Algebra, Algebra 1, Geometry DOK 3 – Transition to Algebra
DOK Application	1 – Measure, Tabulate 2 – Identify Patterns, Modify, Predict, Cause/Effect 3 – Assess, Compare, Investigate, Draw Conclusions
National Standards	9-12: B: Geometry C: Measurement D: Data Analysis and Probability H: Connections
Graduate Research Element	This lesson will allow students to experiment with angles of reflection and how to create lines that do not cross one another. I have to perform a similar process in my research with sections of code. My programs run in parallel, so I must take care not to create sections that interfere (intersect) with one another while they are running.

Student Learning Goal:
After performing this lesson, students will be able to use angles of reflection to produce parallel lines.

This lesson addresses Mississippi 9-12 Mathematics standards: Pre-Algebra 4a and 4c; Transition to Algebra 4a and 5a; Algebra 1 3a; and Geometry 2a. It also addresses National 9-12 Mathematics standards B, C, D, and H.

State Standards: 9^{th} – 12^{th} Mathematics

Pre-Algebra – 4a: Solve real-world application problems that include length, area, perimeter, and circumference using standard measurements.

Pre-Algebra – 4c: Use formulas and/or appropriate measuring tools to find length and angle measures (to appropriate levels of precision), perimeter, area, volume, and

surface area of polygons, circles, spheres, cones, pyramids, and composite or irregular figures.

Transition to Algebra – 4a: Solve real-world problems involving measurements (i.e., circumference, perimeter, area, volume, distance, temperature, etc.).

Transition to Algebra – 5a: Construct graphs, make predictions, and draw conclusions from tables, line graphs, and scatter plots.

Algebra 1 – 3a: Apply the concept of slope to determine if lines in a plane are parallel or perpendicular.

Geometry – 2a: Represent data from geometric and real-world contexts with expressions, formulas, tables, charts, graphs, relations, and functions.

National Standards: 9^{th} – 12^{th} Mathematics

B (Geometry):

- Use visualization, spatial reasoning, and geometric modeling to solve problems

C (Measurement):

- Apply appropriate techniques, tools, and formulas to determine measurements

D (Data Analysis and Probability)

- Develop and evaluate inferences and predictions that are based on data

H (Connection)

- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole

Materials Needed (supplies, hand-outs, resources):

- Mirrors (2 per team)
- Laser pointers
- Protractor
- Graph paper (1 per team)
- Worksheet (see INSPIRE_owens_10_1_12_parallel_lasers_worksheet.doc)
- Various clamps and holders for mirrors and lasers.

Lesson Performance Task/Assessment:

Students will alter the angle between two mirrors to alter the angle of reflection of a laser pointed at the mirrors. The students will fill out the provided worksheet to experimentally determine the angle of reflection required to produce parallel laser lines. They will measure the distance between the laser pointer and the reflected point on the graph paper to determine parallelism.

Lesson Relevance to Performance Task and Students:

The students will modify the angle between the mirrors to demonstrate an understanding of angles of reflection. The students will measure the distance between the laser pointer and reflected point and make adjustments to the mirrors' angle to show an understanding of parallel lines.

Anticipatory Set/Capture Interest:
The lesson will begin with the instructor asking the students, "How do we know that astronauts walked on the moon?" The instructor will then explain that we can confirm that we have been to the moon because astronauts left retro-reflector panels on the surface of the moon that we can shoot lasers at and see return to the same point. The instructor will then play a video of this test (see link in teacher's notes). Finally, the instructor will state that the purpose of today's lesson is to explore the fundamentals of why this test works and lead into the guided practice section.

Guided Practice:
In the guided practice section of this lesson, the instructor will explain the expectations and procedures for the lab. This includes instructions on laser safety and how to alter the angle of the mirrors without breaking them. The instructor will also demonstrate how to properly take measurements of the distance between the laser pointer and reflected point. The instructor will split the class into groups and hand out the worksheet to each team.

Independent Practice:
In the independent practice section, the students will work in groups to fill out their worksheets and determine what angle is required to produce parallel laser lines from the mirrors. They will accomplish this modifying the angle between two mirrors joined at one end. They will aim a laser pointer at one mirror and measure the distance from the laser pointer to the reflected point on a piece of graph paper placed right behind the laser pointer. They will adjust their angle based on observation and inference. The instructor will observe the students and assist with any problems encountered.

Remediation and/or Enrichment:
Remediation: Individual IEP, Give the student a set number of angles to test.
Enrichment: Have the students graph the relationship between distance and the angle of the mirrors from 30 degrees to 60 degrees.

Check(s) for Understanding:
What is angle of reflection? What is the angle between the mirrors? How can you tell if two lines are parallel?

Closure:
To close this lesson, the instructor will ask the class to share results from the experiment. Then, the instructor will ask the students to decide on a comprehensive hypothesis about what angle is necessary to produce parallel lines and why. Finally the instructor will discuss the accuracy of the students' hypothesis and expand on how we see angle of reflection in many places in the real-world such as cat and dog eyes and bicycle reflectors, and explain how parallelism can be used in real-world applications including computer related subjects such as parallel programming.

Possible Alternate Subject Integrations:
Physics

Teacher Notes:

- Care should be taken when using laser pointers.
- The two mirrors can be held using standard lab clamps.
- Retro-reflector Mythbusters video: http://www.youtube.com/watch?v=VmVxSFnjYCA