Lesson Title	Satellite Dish Pointing
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: 3c, 3e Transition to Algebra: 3a, 4a, 4b Algebra 1: 4a Geometry: 1c, 4b, 4e
DOK Level	DOK 2 – Pre-Algebra, Transition to Algebra, Algebra 1, Geometry DOK 3 – Pre-Algebra, Geometry
DOK Application	2 – Predict, Separate, Cause/Effect, Show, Infer 3 – Formulate, Use Concepts to Solve Non-routine Problems, Investigate
National Standards	9-12: B: Geometry C: Measurement E: Problem Solving H: Connections
Graduate Research Element	This lesson teaches students how to align a satellite dish to communicate with satellites in space. My research deals with the audio communication system used by NASA to communicate with astronauts in space. This system uses satellites to bounce signals from mission control to the space shuttle and back.

Student Learning Goal:
After performing this lesson, students will be able to calculate elevation and azimuth angles and orient a mock satellite dish to point at a known location.

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

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

Pre-Algebra – 3c: Explain the Pythagorean Theorem and apply it to solve routine and non-routine problems.

Pre-Algebra – 3e: Use two-dimensional representations (nets) of three-dimensional objects to describe objects from various perspectives.

Transition to Algebra – 3a: Apply the Pythagorean Theorem to solve problems.

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

Transition to Algebra – 4b: Explain and apply the appropriate formula to determine length, midpoint, and slope of a segment in a coordinate plane (i.e., distance formula, Pythagorean Theorem).

Algebra 1 – 4a: Solve real-world problems involving formulas for perimeter, area, distance, and rate.

Geometry – 1c: Solve real-world or application problems that involve square roots and the Pythagorean Theorem.

Geometry – 4b: Solve real-world applications and mathematical problems to find missing measurements in right triangles by applying special right triangle relationships, geometric means, or trigonometric functions.

Geometry – 4e: Apply the relationships of sine, cosine, and tangent to problems involving right triangles.

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

B (Geometry):
- Apply transformations and use symmetry to analyze mathematical situations
- Specify locations and describe spatial relationships using coordinate geometry and other representational systems
- Use visualization, spatial reasoning, and geometric modeling to solve problems

C (Measurement):
- Apply appropriate techniques, tools, and formulas to determine measurements

E (Problem Solving):
- Solve problems that arise in mathematics and in other contexts

H (Connections):
- Recognize and apply mathematics in contexts outside of mathematics

Materials Needed (supplies, hand-outs, resources):
- Lasers (1 per team)
- Object to act as point in space (see teacher's notes)

Lesson Performance Task/Assessment:
Students will calculate elevation and azimuth angles for a mock satellite dish. Students will orient a mock satellite dish to align to a given point in the room.

Lesson Relevance to Performance Task and Students:
Students will work in teams to calculate azimuth and elevation angles for a mock satellite dish. Correctly calculating these angles will demonstrate the students' understanding of angles and the use of triangles as component vectors. Also, the students will orient a physical mock up of the scenario to demonstrate their understanding of the 3-dimensional problem space and how their calculations relate to a physical environment.

Anticipatory Set/Capture Interest:
As an anticipatory set for this lesson, the instructor will pose the question, "Does anyone know how we communicate with astronauts while they are in space?" The instructor will then explain that we do this by using satellites, and that in order to use satellites we must use geometry to align them with the dishes on the ground.

Guided Practice:
In the guided portion of the lesson, the instructor should go over the key concepts necessary to complete the exercise:

- Satellite pointing: Adjusting a satellite dish's platform to align it to the satellite in space.
- Elevation angle: "Elevation refers to the angle between the dish pointing direction, directly towards the satellite, and the local horizontal plane. It is the up-down angle. "
- Azimuth angle: "Azimuth refers to the rotation of the whole antenna around a vertical axis. It is the side to side angle. Typically you loosen the main mount bracket and swing the whole dish all the way around in a 360 deg circle."
- component vectors

The instructor should also outline the steps that must be completed to finish the activity:

1. Measure your distance to the "satellite."
2. Make scale drawings of the environment.
3. Calculate the component vectors.
4. Calculate the elevation and azimuth angles.
5. Align laser platform to correspond to calculations.

Independent Practice:
In the independent section of the lesson, the students will perform the steps outlined in the guided portion of the lesson. The instructor will separate the students into teams of 3-5 and assign them a location in the room to position their "satellite dish." The instructor will then allow the students to complete the tasks on their own, providing assistance when necessary.

Remediation and/or Enrichment:
Remediation: Individual IEP.
Enrichment: Have the students calculate the true distance from their "dish" to the "satellite."

Check(s) for Understanding:
What is the elevation angle? What is the azimuth angle? What are the horizontal component vectors for your satellite dish? What are the vertical component vectors for your satellite dish?

Closure:
In the closure section of this lesson, the instructor will have each team demonstrate their dish's alignment. Then, the instructor will lead a discussion on the methods the teams used to set up their platforms. Finally, the instructor will give the students examples of how scientists and regular people have to make these calculations every day, specifically how computer engineers use this process to communicate with astronauts in space.

Possible Alternate Subject Integrations:
Physics

Teacher Notes:

- Care should be taken when using laser pointers.
- An object can be hung from the ceiling to act as a stand-in satellite that the students should hit with their lasers after aligning their platforms.