Exploring Geometry Through the *Chariot of Aurora*

Grade
- 9–12

Teacher-In-Residence
- Jesse Baker

Subjects
- Geometry

Carnegie Museum of Art

Goals

- Students will be able to analyze the sculpture relief *Chariot of Aurora* both artistically and geometrically.

- Using equations and geometrical ideas, students will be able to create a work of art.

- Students will be able to write geometrical directions so that a partner can recreate their original work.

Objectives

- Students will make mathematical connections with the massive sculpture relief *Chariot of Aurora*.

- Students will create a paper quadrant that can be duplicated using geometry.

- Students will use mathematical vocabulary to communicate with a partner effectively.

Standards

PA Core Standards

• **CC.2.3.8.A.2** Understand and apply congruence, similarity, and geometric transformations using various tools

• **CC.2.3.HS.A.3** Verify and apply geometric theorems as they relate to geometric figures.

• **CC.2.3.HS.A.13** Analyze relationships between two-dimensional and three-dimensional objects.

• **CC.2.3.HS.A.1** Use geometric figures and their properties to represent transformations in the plane.

• **CC.2.3.HS.A.2** Apply rigid transformations to determine and explain congruence.

• **CC.2.3.HS.A.5** Create justifications based on transformations to establish similarity of plane figures.

• **CC.2.3.HS.A.6** Verify and apply theorems involving similarity as they relate to plane figures

• **CC.2.3.HS.A.8** Apply geometric theorems to verify properties of circles.

• **CC.2.3.HS.A.11** Apply coordinate geometry to prove simple geometric theorems algebraically.

• **CC.2.3.HS.A.9** Extend the concept of similarity to determine arc lengths and areas of sectors of circles.

• **CC.2.3.HS.A.14** Apply geometric concepts to model and solve real-world problems.

• **CC.2.2.HS.C.2** Graph and analyze functions and use their properties to make connections between the different representations.

• **CC.2.2.HS.C.3** Write functions or sequences that model relationships between two quantities.

• **CC.2.2.HS.C.2** Graph and analyze functions and use their properties to make connections between the different representations.

• **CC.2.2.HS.D.7** Create and graph equations or inequalities to describe numbers or relationships.

Arts and Humanities 9.1.8.B. Know

and use the elements and principles of each art form to create works in the arts and humanities.

Arts and Humanities 9.2.8.H.
Explain that instruments or art forms represent cultural perspectives.

National Core Arts Standards

- **Anchor Standard 1** Generate and conceptualize artistic ideas and work.

- **Anchor Standard 2** Organize and develop artistic ideas and work.

- **Anchor Standard 8** Interpret intent and meaning in artistic work.

- **Anchor Standard 10** Synthesize and relate knowledge and personal experiences to make art.

Materials

- Graph paper
- Lined paper
- Ruler
- Compass
- Patty paper (if applicable)
- Colored pencils
- Crayons or markers

Vocabulary

Use all applicable vocabulary from current mathematics unit. For example, in a geometry unit, vocabulary could include:

- Point
- Line
- Plane
- Obtuse
- Right
- Acute
- Scalene
- Isosceles
- Equilateral
- Circle
- Arc
- Parallelogram
- Rhombus

Art vocabulary includes:

- Shape
- Line
- Color
- Value
- Texture
- Space
- Form
- Contrast
- Unity

Artwork

Jean-Théodore Dupas, *Chariot of Aurora*, 1935, Gift of Frederick R. Koch, 94.242.A-.FF

Lesson

This lesson is designed to take at least two days.

Introduction:
Navigational angles between the horizon and selected celestial objects are used to locate a position on the globe, and those angles translate directly to the mathematical models of geometry and trigonometry of assignments within the latest Pittsburgh Public Schools math curriculum. Angles are the most common type of numbers that celestial navigators calculate. The position of celestial bodies and other points on the surface of the earth can be defined and located by a description of angles. The quadrant is the preferred instrument for measuring those angles.

Main Activity:
Celestial navigation is the art and science of finding one's geographic position by means of astronomical observations, particularly by measuring altitudes of celestial objects—sun, moon, planets, or stars. This activity starts with a basic, but very important and useful, celestial measurement: measuring the altitude of Polaris (the North Star) or measuring the latitude.

How did ancient navigators planning to sail out of sight of land stay on course and return home?
Answer: They measured the altitude of Polaris, the North Star, when they left home port. In today's terms, this would be called measuring the latitude of the home port.

How did knowing the latitude of Polaris enable them to find their ways home?
Answer: To return after a long voyage, early navigators needed only to sail north or south, as appropriate, to bring Polaris to the altitude of homeport. Then they would turn left or right, as appropriate, and "sail down the latitude," keeping Polaris at a constant angle.

In this activity, you will learn the basics of celestial navigation. Before the activity, have students See, Think, Wonder on Meditation on Rebirth for the Winter Solstice

• Decide whether to have students make paper or protractor quadrants (see below). If paper is chosen, make enough copies of the *Make a Paper Quadrant–Instructions Sheet*.
• If you want students to be able to take home/keep their quadrants,

then have them work individually, rather than in pairs.
• Print one or more copies of the Star Trails Sheet.
• Cut out a paper star or picture of a star and place it high in the center of a classroom wall (the higher, the better!) to serve as the classroom's North Star.

Each group needs: Make a Paper Quadrant–Instructions Sheet (pdf) and Polaris Latitude Worksheet (pdf)
• 1 straw or 12-inch ruler (straws if students will keep the quadrants)
• 1 piece of string (about 6 inches)
• 1 sheet of poster board or stiff paper (such as two pieces of construction paper glued together)
• 1 small weight (such as a washer, metal nut, or any small, heavy object)
• Tape
• 1 pencil

1. Give each student a *Make a Paper Quadrant–Instructions Sheet* and follow the instructions.
2. Direct students to determine the relative latitude of their desks by positioning their eyes, along with their quadrants, level with the edge of their desks.
3. Find the classroom's North Star elevation by sighting through the straw, or by touching a ruler to your cheekbone (under your eye) and then pointing the other end directly at the star.
4. Let the weight swing freely until it stops so that the string is hanging straight down.
5. Have your partner read the scale. If working alone, slightly tilt the stick so that the string touches the quadrant scale. Then with your finger and thumb, hold the string against the scale, and bring the scale end around where you can read it. Record this measurement on the back of your worksheet.
6. Trade positions with your partner and have them take a second measurement. Record this measurement on the back of your worksheet.

Assessment

After sharing the "Meditation on Rebirth for the Winter Solstice," students will individually create an artwork through collaboration, with the understanding that each line, curve, and shape on the piece will have to be created using geometrical ideas (e.g., using rigid transformations on a triangle or quadrilateral). Students will show their knowledge of geometry terms by creating art. Each student is given a piece of paper and instructions (such as "make 3 dots"). Students should follow the instructions, then write out their own geometrical directions (such as "use a compass to create 3 circles from the 3 dots. Then they pass their sheet of paper. Students draw on their peers' paper following the given instruction, provide a new instruction, then pass the paper. Papers get passed around until they reach their "owner." The owner embellishes the line drawing to create a unique piece of art. Students will then display their art through a gallery walk. Traditionally, a gallery walk is an active teaching strategy that lets students walk around the classroom to read, analyze, and evaluate other students' work. They would then provide feedback or offer ways to improve others' ideas through written notes or verbal comments.

Questions:
After each student has created both their artwork and artwork based on a partner's directions, students should reflect upon the experience.
- Did the art created from the directions match the original piece?
- If not, was the error in the written directions or with the artist? Did the directions allow for multiple possibilities?
- What was difficult about this activity? What would you do differently if we were to do this activity again?

Assessments:
Students can be assessed on the accuracy of their written mathematical directions and on their accuracy in following the directions to create the second artwork.

Lesson Extensions and Modifications

• IEP Modifications: Students with special needs may use different criteria, including a reduced number of expectations and/or more basic figures.

• Artistic Extension: Students should choose a color scheme (achromatic, monochromatic, complementary, split complementary, triadic, or analogous) to complete their artwork and explain why they chose that scheme.

• Mathematical Extension: “Change one thing” in the written directions and describe how changing one value changes the artwork.