Lesson Title: Celestial Sphere Rotations Activity
Amount of time for this lesson = 55 minutes, High School CCSS Mathematics

1. Pre-lesson: have Google App Planetarium website open at http://neave.com/planetarium/ as well as have this lesson open.
2. Standards and Safety and Materials:

   A. Standards – CCSS for High School Math:
   G-CO: Experiment with transformations in the plane
   1. Know precise definitions of angle, circle…based on the undefined notions of…distance around a circular arc.
   2. Represent transformations in the plane using, e.g., transparencies and geometry software…
   3. Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations…that carry it onto itself.
   4. Develop definitions of rotations…in terms of angles, circles,…
   5. Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g.,… geometry software…
   G-CO: Understand congruence in terms of rigid motions
   6. Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.

   B. Safety Concerns: minimal safety concerns with regular class activity.

   C. Materials: Student activity handout, protractor, Google Chromebook with free Planetarium App for Chromebooks downloaded (or a Windows machine with website http://neave.com/planetarium/ open).

3. Objectives:
   A. Students will be able to **use** an online Interactive Star Map and Virtual Sky entitled Planetarium.
   B. Students will be able to **define and apply** the terms celestial sphere, northern celestial pole, and zenith in a virtual setting.
   C Students will be able to **define and apply** the terms geometric rotation, center of rotation, and angle of rotation.
   D. Students will be able to **apply** protractor skills.
   E. Students will be able to **model** geometric rotations using Planetarium.
   F. Students will be able to **determine** the affect(s) of a rotation on a given figure.

4. Connections, Misconceptions, and Crosscutting Concepts:
   A. Real world connections: Astronomer, astronaut, mathematician/teacher, angular rotation of sky as a clock (camping)..
   B. Student connections: stars in the sky, familiar constellations, telescope viewing.
   C. Misconceptions: concept of celestial sphere representing the night sky, north pole on earth being the north celestial pole and zenith at the same time.
   D. Crosscutting Concepts: patterns, movements in 2-D, science/astronomy.
   E. Academic Language: geometric rotation, center of rotation, and angle of rotation; celestial sphere, northern celestial pole, and zenith

5. Catch/*Engagement*: Show the video to illustrate the concept of a celestial sphere at
https://www.youtube.com/watch?v=TAFvN83NZAc (1:44). Then show video that further explains more details of the concept of celestial sphere at ***https://www.youtube.com/watch?v=1Toya19H12w*** (2:44).

6. Pre-test:
   1. What is a sphere?
   2. What does the word celestial mean?
   3. What is the North Pole?
   4. What does it mean in geometry to rotate a figure? What units are rotations measured in?
   5. What is the mathematical tool protractor used for?
   6. What happens to a figure when it is rotated? What DOESN'T happen to a figure when it is rotated?

Introduction: (student copy will be fill-in-the-blank in underlined areas)

- **Go over pre-test.**
- **Ask students if the videos have any connections to the pre-test.**

Procedure:
   A. **Use a random or pre-determined method to pair up students.**

B. Issue Student Handouts:
1. Show North Pole Youtube video of recent years: ***https://www.youtube.com/watch?v=Px4DqMszDDY***
2. Using SMART Board, direct students on where to go to on their Chromebooks to download (quick & free) the Google Chrome App Planetarium.
3. Explain how to get started, including:
   o What the menu at the bottom of the screen is all about;
   o how to set the location roughly at the North Pole (earth);
   o and how to get to a location so that the North Celestial Pole is right above us (in other words, our Zenith).
4. Explain that the padlock means the Planetarium is locked in the present time.
5. Demo to students what happens when you hold the mouse over the padlock and click to unlock it. Explain that you can now go forward or backward in time. Have students explore for 10 seconds on each button, both arrows. Discuss as a class when finished.
6. Ask students if they know what the star is called in the center of the screen. Then ask if anybody knows the name of the constellation (Ursa Minor, Little Bear, Little Dipper).
7. Now have students focus on the Little Dipper while they change numbers in the time menu. Tell them to discuss with each other what is happening to the Little Dipper as time changes. Discuss as a class, and ask them why they think this happens.
8. Review on white board on how to use a protractor. Then have students draw an angle less than 90° and measure it. Have their partner check it.
9. Then have students draw an angle more than 90° and measure it. Have their partner check it.
10. Pose the question: As Ursa Minor is rotating in the night sky, ROUGHLY where is the center of the rotation. Have pairs discuss, then discuss as a class.
11. Pose the problem: Using your protractor on your computer screen, find out how many degrees Little Bear will rotate in 6 hours? Discuss.
12. Pose the problem: Using your protractor on your computer screen, find out how many degrees Little Bear will rotate in 3 months? Discuss. Be sure to bring up that they are both 90° and discuss as a class why.
13. Have student pairs complete the following table using Planetarium and their protractor:

Set to this Year	Measured Angle of Rotation	Set the month to:	Measured Angle of Rotation
2012	Starting point	January	Starting point
2013		April	
2014		July	
2015		October	
2016		Back to January	

What happened to the Little Dipper when you changed from 1 year to the next? Why does this happen?

What happened to the Little Dipper when you changed to 3 months later? Why does this happen?

Set to this # of hours	Measured Angle of Rotation
0 0	Starting point
6	
12	
18	
24	
0 0	

What happened to the Little Dipper when you changed to 6 hours later? Why does this happen?

14. When finished with the tables, compare with another group.
15. Discuss tables as a class using volunteer groups.
16. Have students explain IN GENERAL what is happening in ONE thing that they did, using the following terms: Little Dipper, rotate, rotation, center of rotation, angle of rotation.
17. Have a few students read theirs to the class. Discuss.

7. Review/Essential Questions/*Explanation*: (Should be very closely related to your pre/post tests! Explanation piece…)
       All was described and built into what occurred earlier.

8. Assessments (Post-test)/*Evaluation*:
Give Pre-test again as Post-test:
1. What is a sphere?
2. What does the word celestial mean?
3. What is the North Pole?
4. What does it mean in geometry to rotate a figure? What units are rotations measured in?
5. What is the mathematical tool protractor used for?
6. What happens to a figure when it is rotated? What DOESN'T happen to a figure when it is rotated?

10. Enrichment/*Elaboration*: For extra credit, challenge students to find a career that uses geometric rotations besides astronomer. They must be specific as to how, and cite their source.

11. IEP Accommodations/Differentiation/Diversity: What accommodations will you use to support struggling learners?

- Assure 2 special needs students are not paired.
- Be sure it is very quiet when appropriate.

1. Standards:

    A. CCSS for High School Math:
    G-CO: Experiment with transformations in the plane
    1. Know precise definitions of angle, circle…based on the undefined notions of…distance around a circular arc.
    2. Represent transformations in the plane using, e.g., transparencies and geometry software…
    3. Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations…that carry it onto itself.
    4. Develop definitions of rotations…in terms of angles, circles,…
    5. Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g.,… geometry software…
    G-CO: Understand congruence in terms of rigid motions
    6. Use geometric descriptions of rigid motions to transform figures and to predict the effect of a given rigid motion on a given figure; given two figures, use the definition of congruence in terms of rigid motions to decide if they are congruent.

    B. Materials: Student activity handout, protractor, Google Chromebook with free Planetarium App for Chromebooks downloaded (or a Windows machine with website http://neave.com/planetarium/ open).

2. Objectives:
    A. You will be able to **use** an online Interactive Star Map and Virtual Sky entitled Planetarium.
    B. You will be able to **define and apply** the terms celestial sphere, northern celestial pole, and zenith in a virtual setting.
    C You will be able to **define and apply** the terms geometric rotation, center of rotation, and angle of rotation.
    D. You will be able to **apply** protractor skills.
    E. You will be able to **model** geometric rotations using Planetarium.
    F. You will be able to **determine** the affect(s) of a rotation on a given figure.

3. Connections, Misconceptions, and Crosscutting Concepts:
    A. Real world connections: Astronomer, astronaut, mathematician/teacher, angular rotation of sky as a clock (camping).
    B. Student connections: stars in the sky, familiar constellations, telescope viewing.
    C. Crosscutting Concepts: patterns, movements in 2-D, science/astronomy.
    D. Academic Language: geometric rotation, center of rotation, and angle of rotation; celestial sphere, northern celestial pole, and zenith

4. Pre-test:
    A. What is a sphere?

    B. What does the word celestial mean?

    C. What is the North Pole?

    D. What does it mean in geometry to rotate a figure? What units are rotations measured in?

    E. What is the mathematical tool protractor used for?

    F. What happens to a figure when it is rotated? What DOESN'T happen to a figure when it is rotated?

Procedure:

A.
1. Posed problem: Using your protractor on your computer screen, find out how many degrees Little Bear will rotate in 6 hours?

2. Posed problem: Using your protractor on your computer screen, find out how many degrees Little Bear will rotate in 3 months?

3. With your partner, complete the following table using Planetarium and a protractor:

Set to this Year	Measured Angle of Rotation	Set the month to:	Measured Angle of Rotation
2012	Starting point	January	Starting point
2013		April	
2014		July	
2015		October	
2016		Back to January	

What happened to the Little Dipper when you changed from 1 year to the next? Why does this happen?

What happened to the Little Dipper when you changed to 3 months later? Why does this happen?

Set to this # of hours	Measured Angle of Rotation
0 0	Starting point
6	
12	
18	
24	
0 0	

What happened to the Little Dipper when you changed to 6 hours later? Why does this happen?

4. When finished with the table, compare with another group.
5. IN GENERAL what is happening in ONE thing that you did, using the following terms: Little Dipper, rotate, rotation, center of rotation, angle of rotation.

8. Post-test:
1. What is a sphere?

2. What does the word celestial mean?

3. What is the North Pole?

4. What does it mean in geometry to rotate a figure? What units are rotations measured in?

5. What is the mathematical tool protractor used for?

6. What happens to a figure when it is rotated? What DOESN'T happen to a figure when it is rotated?

10. Enrichment/*Elaboration*: For **extra credit**, find a career that uses geometric rotations besides astronomer. You must be specific as to how, and cite your source(s).