# ECLIPSES AND CELESTIAL MECHANICS LESSON

**ESSENTIAL QUESTION**
How does programming help us model movements of bodies in our solar system?

**TOPICS**
Astronomy
Physics
Computer Science
Modeling

**OVERVIEW**
Demonstrate the magic of eclipses with your Ozobots, and explore lunar phases, orbits and celestial mechanics with our Earth and Moon!

In 2017 (on August 21st to be exact) there was a **total solar eclipse** across the contiguous United States, and only a sliver of the country could see it in full. For anyone who caught a glimpse, it left a lasting reminder about how cool our little solar system is!

Send your students off to orbit with this project where they find out what is really happening when shadows cross over the Moon and the Earth in a demonstration using 2 Ozobots and a flashlight. Then they will observe the orbital mechanics of two bodies in the vacuum of space (modeled with Earth and the Moon) and plot OzoCodes to model that behavior with an Ozobot. They are welcome to study eclipses and Moon phases on their own with this map.

For advanced students, you can choose to challenge them to recreate the path that the total solar eclipse took across the United States by making sure certain US cities are under its path. A possible solution is provided for you.

**PREREQUISITES**

- Students will be using pen and paper so they should be comfortable with. OzoCodes. See Ozobot Basic Training Lesson 1
- For optional OzoBlockly challenge, students should know how to program with OzoBlockly (See Ozoblockly Basic Training).

## GROUPING

For the activity, students can be in pairs with one Ozobot.  For the demonstration, the instructor will use two Ozobots (Bit or Evo, or mixed).

## MATERIALS

2 bots for the teacher demonstration (or prop with similar dimensions)
1 Bit or Evo per group
1 Marker set per group
OzoCodes reference sheet
Print-outs of 'Moon's Orbit'
1 Flashlight (or phone)
Optional: Desktops or tablets for the OzoBlockly optional activity
Optional: Print outs of USA map

## GRADE LEVEL

Grades 3 through 12

## OZOBLOCKLY PROGRAMMING TOPICS

Modes 3 and 4: Rotation, setting wheel speeds, move a distance (in metric), iterators, math.

## DURATION

40 minutes (or 55, with extensions and advanced activity)

## ACADEMIC STANDARDS

**ISTE 1.c** Use models and simulation to explore complex systems and issues.
**ISTE 4.b** Plan and manage activities to develop a solution or complete a project.
**ISTE 6.a** Understand and use technology systems.
**NGSS HS-ESS1-4** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
**NGSS MS-ESS1-1** Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.
**NGSS MS-ESS1-2** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.
**NGSS MS-ETS1-2** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
**NGSS MS-ETS1-3** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
**NGSS MS-ETS1-4** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

**NGSS 5-ESS1-2** Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
**NGSS 3-5-ETS1-1** Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
**NGSS 3-5-ETS1-2** Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
**NGSS 3-5-ETS1-3** Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
**NGSS 3-PS2-2** Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

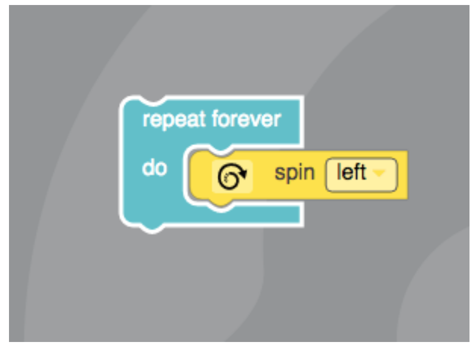
**QUESTIONS ABOUT THIS LESSON?**
Please contact us at ozoEdu@ozobot.com

# LESSON

## PREPARATION

You will need to print out one 'Moon's Orbit' and **blacken out** the codes (optionally, keep one code space for "slow"), and have a flashlight and two Ozobots for the demonstration. Then, have one or two Ozobots for each pair of students and print copies of 'Moon's Orbit' for each group. You may want extra as mistakes do happen!

You may also want to code a short program for your Earth Ozobot to spin "forever." You can use the following code in OzoBlockly:




Otherwise, you can blacken out the Earth and set up your Earth Ozobot to trace its outline.

## PART 1: ECLIPSE DEMONSTRATION

Demonstrate for your students (or allow them to do so in groups) how the Moon travels around the Earth at a slight ellipse. Show the students the **blacked-out** copy 'Moon's Orbit'. Set up one Ozobot on the center Earth to spin with the OzoBlockly program, or blacken the dot so that it follows the border of the circle in a counterclockwise direction to mimic the rotation of the Earth.

Next, set up the second Ozobot to follow the **blacked-out** elliptical orbit in a counterclockwise direction.

Finally, place your flashlight at the light source (our Sun!) and turn down the lights. Students should see that:

1. The Moon will block the Sun for the Solar Eclipse
2. The Earth blocks the Sun for the Lunar Eclipse

## PART 2: OZOCODE ACTIVITY

### STEP 1

If your students are already aware of how gravity pulls objects, and how the closer an object is the faster it goes, then they can go straight to **Step 2**. If not, here are some ideas to practice:

1. If you have a spinning chair, have students demonstrate how extending their limbs slows down the spin but holding them in makes them faster;
2. Two students can hold both hands and spin around at arm's length. Have students pull in together as they spin and see how they go faster.

These activities demonstrate angular momentum, and gives students the idea of how orbits work. (If you want to, you can get into about how gravity wells work!) For a 2D demonstration, see resource #5.

### STEP 2

Once it is established that objects close to a larger body go faster than when they are further away, go ahead and give each pair of students (or individual) a blank 'Moon's Orbit' sheet and point out the OzoCodes listed on that sheet which are recommended for the activity. Have your students put the correct codes to model the motion of bodies that orbit in an elliptical path.

There are extra blank spaces that should be blacked out by the students. They may realize through trial and error that codes in a curve don't work; or, you can give them the hint that not all spaces will be needed. Prior experience may have taught them already that OzoCodes on steep curves don't work well.

Afterwards, students can study the eclipse events on their own by setting up two Ozobots on the newly coded track, and use a flashlight to witness the eclipses and lunar phases.

Questions that you can ask your students during the demo:

1. Why don't we get eclipses every month, since the model demonstrates that should be possible? (Answer: Moon also wavers up and down in its orbit, so being in line between the Sun and Earth happens rarely (see resource #2)).
2. Why are eclipses so short?
3. What phase of the moon should there be for a lunar eclipse? For a solar eclipse?

## OPTIONAL ADVANCED ACTIVITY

### STEP 1

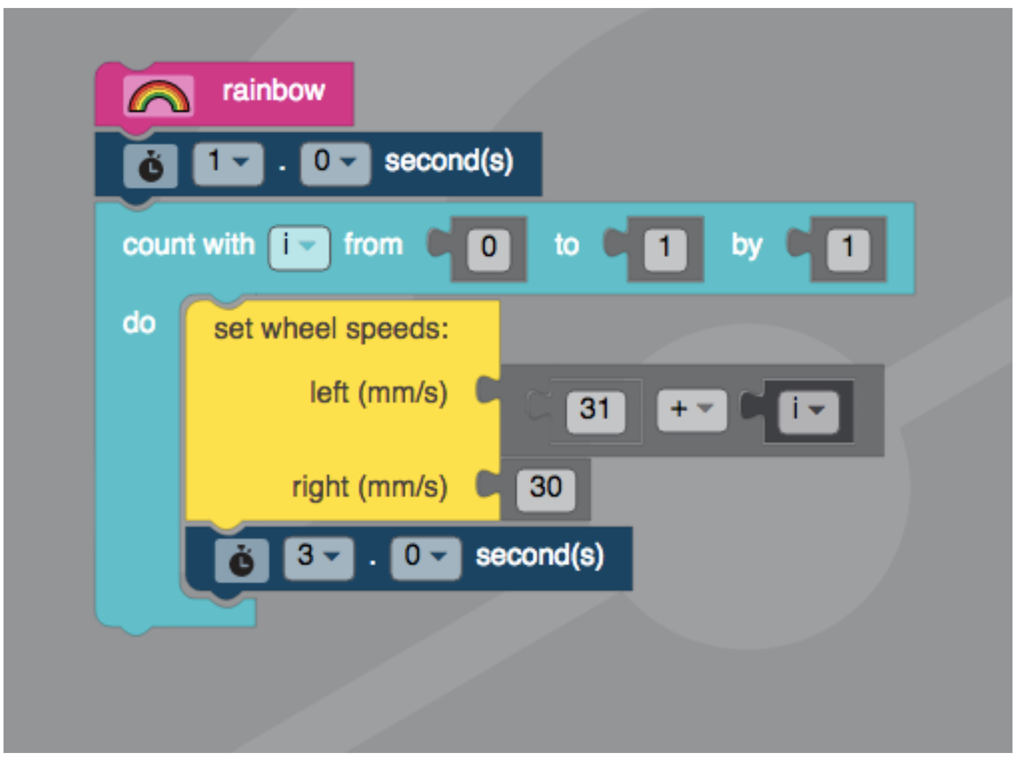
With the map of the United States provided, students plot the cities mentioned in this Space.com article which are directly in line with the eclipse.

### STEP 2

Have students explore Modes 3 and 4 of OzoBlockly and figure out how to code the slowly sloping path. They can either figure out a way to make it slope, or have the Ozobot reach each city using rotation and forward movement (be sure to choose 'bit' or 'evo' when building code). The direction of Ozobot must also be accurate.

Students can share their model of the sloping path to the class.

Example solution for the sloping path:




Please note: your wheel speeds may need to be different than shown here. This code approximately traverses the slope from Portland, Oregon to Columbia, South Carolina. Acceptable answers can also include city to city straight lines with degree rotation. Initial time delay allows you to adjust direction of the Ozobot when placing onto the map.

## POST ACTIVITY

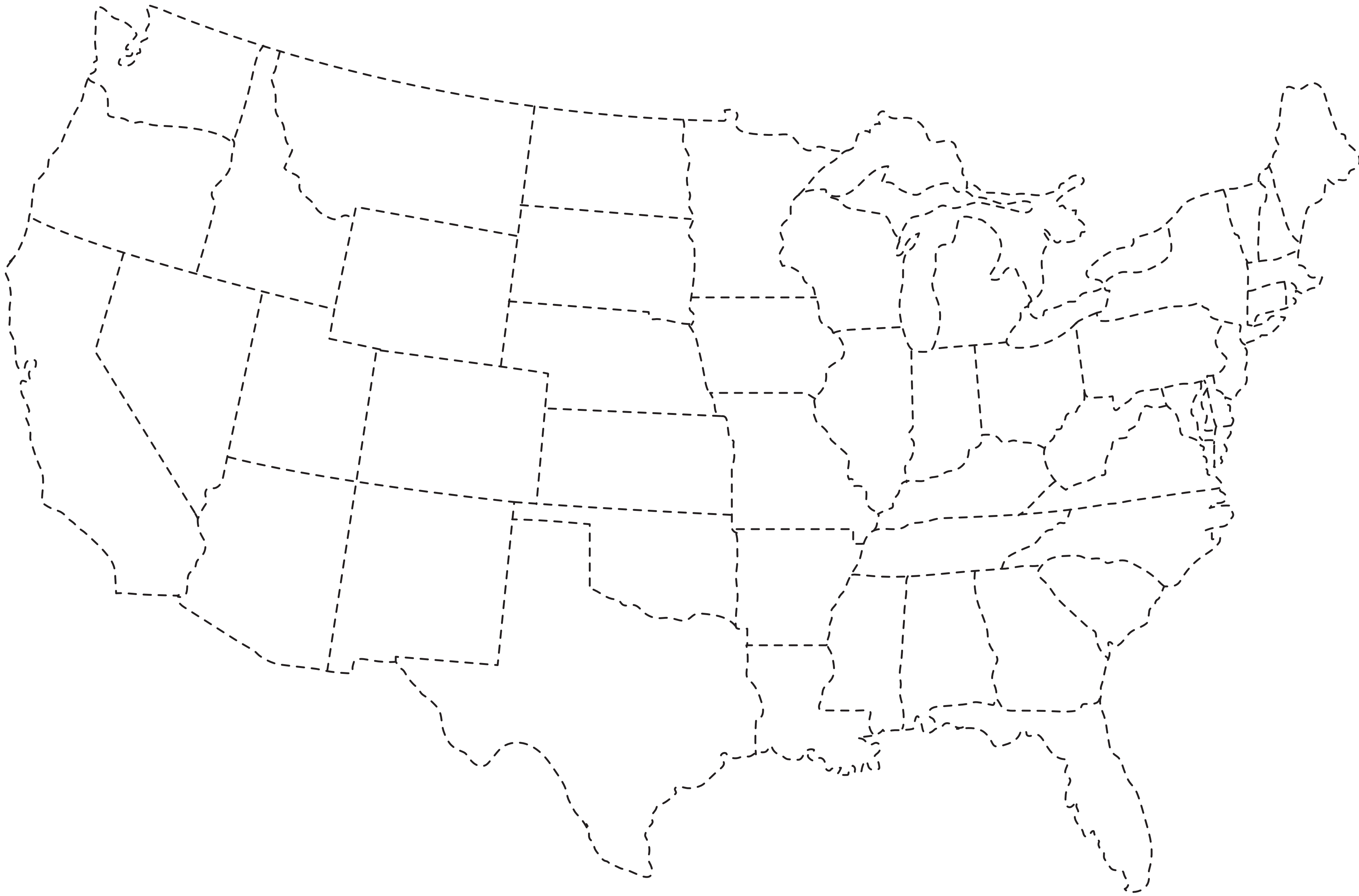
Have your students reflect on how programming can be used to model nature, especially at the astronomical level. Have them come up with ideas of other things they can model in space with their Ozobots, and perhaps they can demonstrate their activity another day!

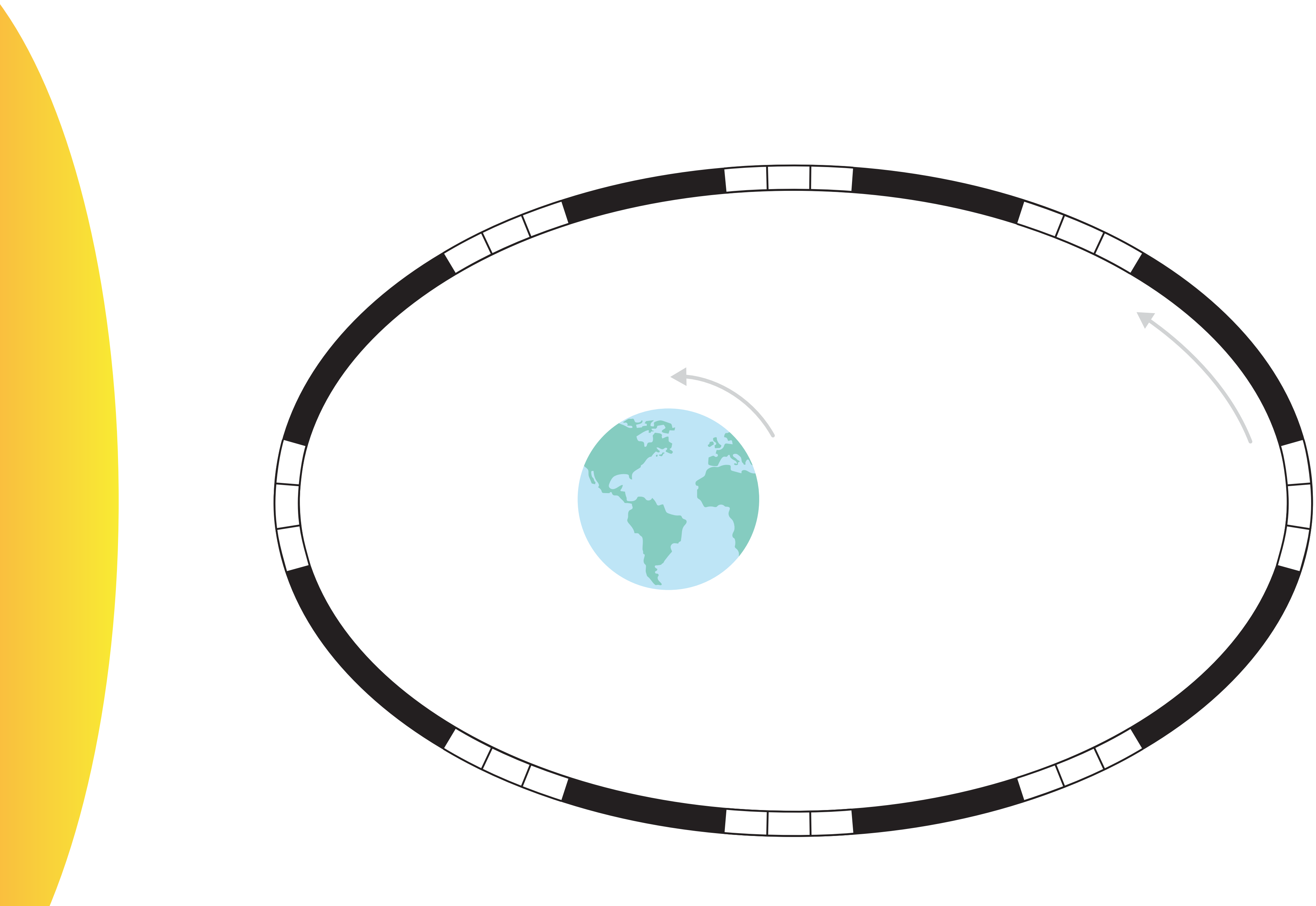
## EXTENSIONS

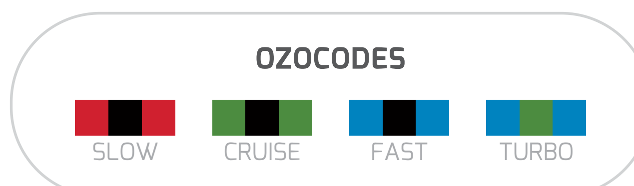
You can reuse this activity to demonstrate **Lunar Phases.** In this case, it may be better to code the whole track as slow in order to appreciate the phases as observed from the Earth. Or, code pauses at each major phase location.

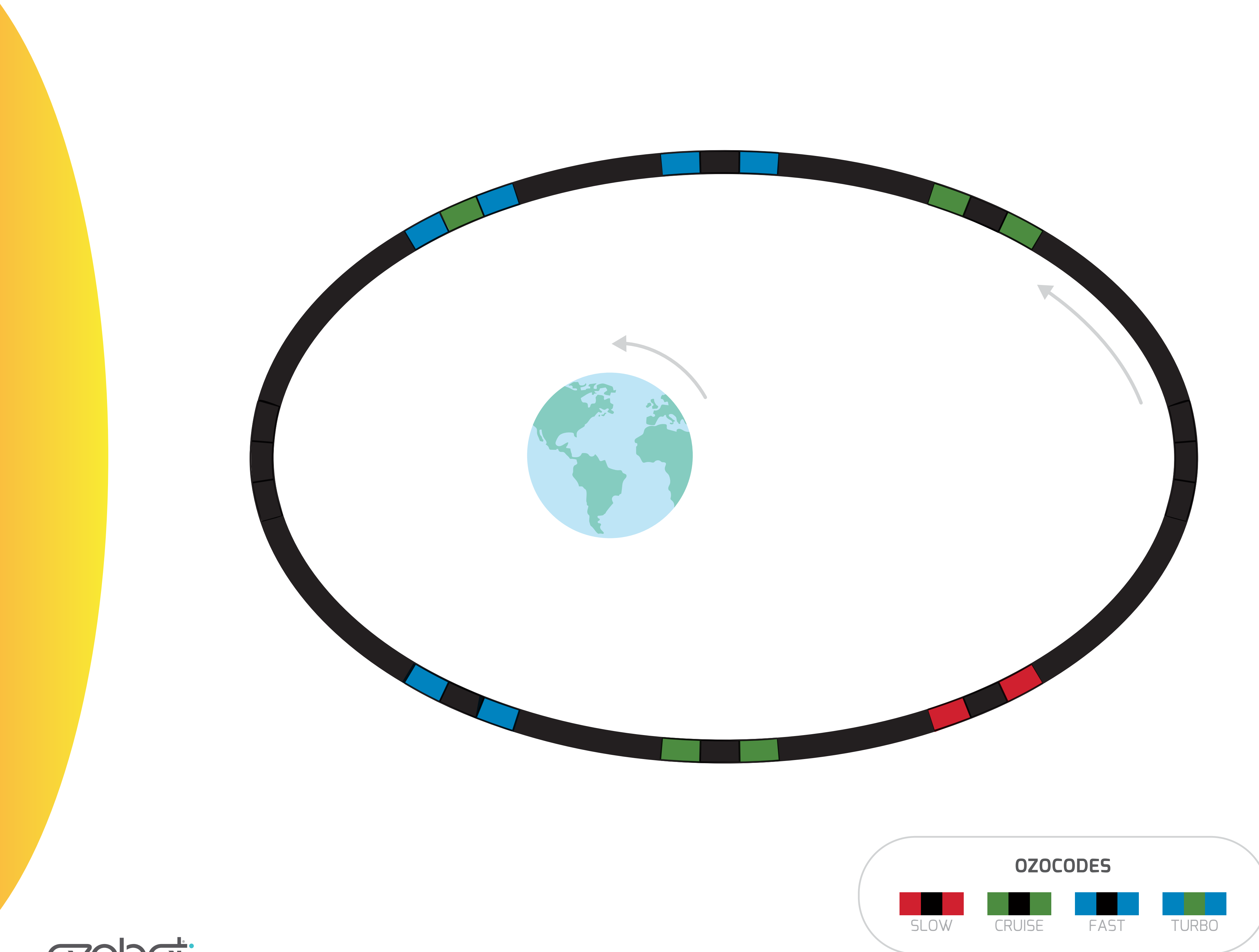
## EXTRA RESOURCES

1. This article is full of fun facts about Solar Eclipses. This will be great to show after the challenge activities. http://cs.astronomy.com/asy/b/astronomy/archive/2014/08/05/25-facts-you-should-know-about-the-august-21-2017-total-solar-eclipse.aspx
2. Within the above article is a wonderful chart showing the dates and areas of recent and future Solar Eclipses. http://cs.astronomy.com/cfs-file.ashx/__key/communityserver-blogs-components-weblogfiles/00-00-00-00-51-Solar+system+objects/5822.2008_2D00_2028eclipses.jpg
3. This page is a great starter page about Solar Eclipses (you can find Lunar Eclipses, too) for budding astronomers in your class. http://www.mreclipse.com/Special/SEprimer.html
4. A great map that shows cities under the eclipse http://totaleclipsecolumbiasc.com/wp-content/uploads/2016/11/tse-web-maps_6968w-01-2.png
5. A video demonstrating angular momentum and Kepler's Second Law for conservation of angular momentum in an elliptical orbit. (Start at 5:20) https://www.youtube.com/watch?v=6TGCPXhMLtU






OZOCODES
SLOW
CRUISE
FAST
TURBO




Moon's Orbit: Solution