



# celestial jukebox

Informal Lesson



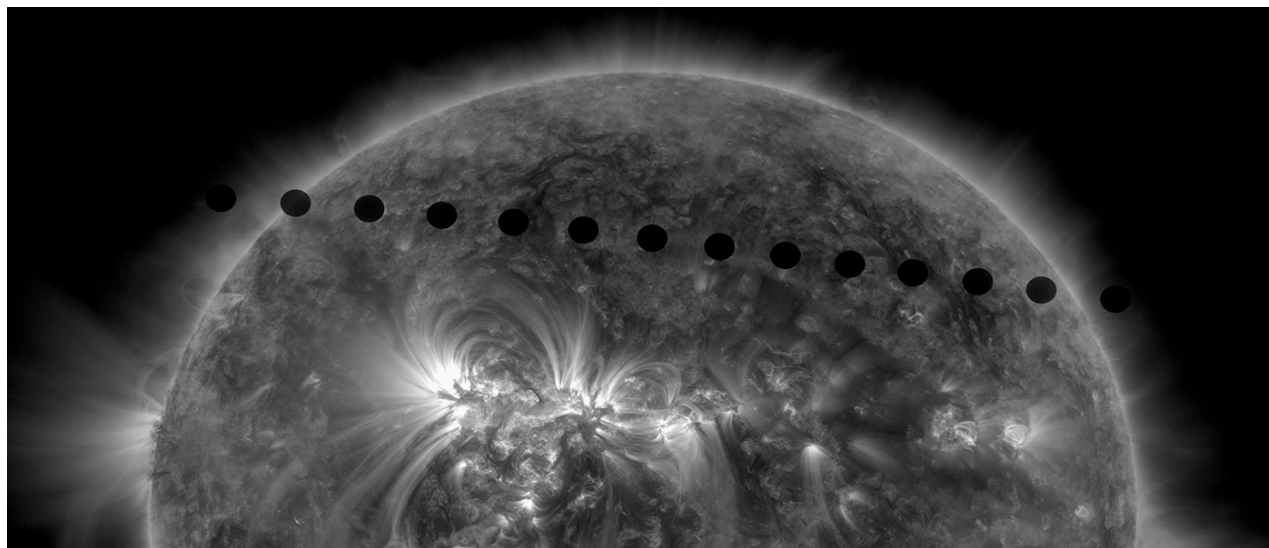


## Celestial Jukebox

Grades: 9-12

Prep Time: ~10 min

Activity Time: ~45 minutes



### WHAT LEARNERS DO: Use a model to derive Kepler's Third Law.

Learners will use the pattern of sound to observe transits. They will derive Kepler's Third Law from the data they collect within our solar system. Then they will apply Kepler's Third Law to extrasolar systems and the search for exoplanets while collecting rare coins along the way.

#### NRC FRAMEWORK/NGSS CORE & COMPONENT QUESTIONS

### WHAT IS THE UNIVERSE, AND WHAT IS EARTH'S PLACE IN IT?

NGSS Core Question: ESS1: Earth's Place in the Universe

### What are the predictable patterns caused by Earth's movement in the solar system?

NGSS ESS1.B: Earth and the Solar System

#### INSTRUCTIONAL OBJECTIVES (IO)

*Learners will be able to*

**IO1: Develop and use a model of the solar system to derive Kepler's 3rd Law and apply the equation to search for exoplanets in orbit around their stars.**

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## 1.0 Materials

### Required Materials

#### Please supply:

- Computer or laptop – 1 per learner
- Supported Browsers: Chrome; Edge; Firefox; Safari

#### Please Print:

#### From Learner Guide

- (A) Transit Examples – 1 per small group

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## 2.0 Activity Timeline

### Celestial Jukebox Activity Timeline:

Time:

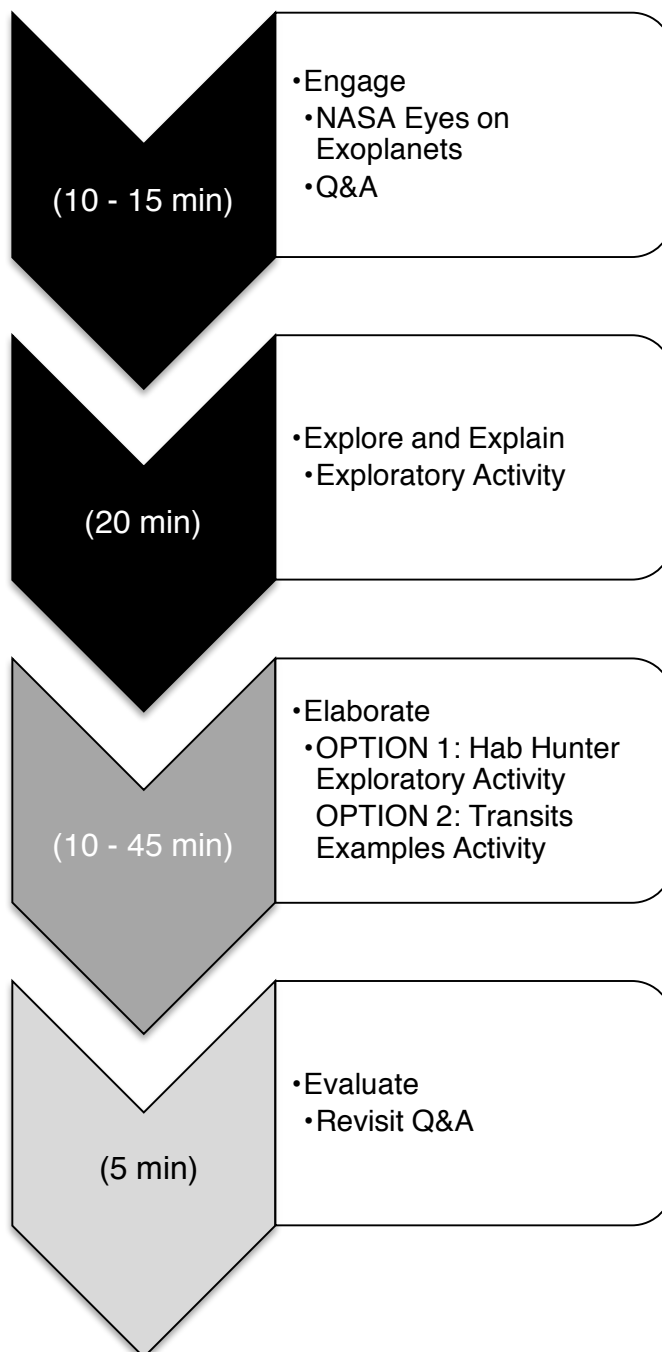
- 45 - 85 minutes

Materials:

- Learner Guide page
- Computer or laptop

5-E Inquiry Process:

- The arrow color represents the 5-E step learners will be primarily engaging in for that session



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### 3.0 Vocabulary

<b>astronomical unit</b>	a unit of measurement that represents the average distance between Earth and the Sun
<b>distance</b>	the length of a straight line between two points
<b>exoplanet</b>	a planet that orbits a star outside the solar system
<b>exponent</b>	a number representing how many times a value should be multiplied by itself
<b>extrasolar systems</b>	solar systems with exoplanets in orbit around their stars
<b>frequency</b>	how often an event occurs
<b>function</b>	a relationship or expression involving one or more variables
<b>model</b>	a simulation that helps explain natural and human-made systems and shows possible flaws
<b>observations</b>	specific details recorded to describe an object or phenomenon
<b>orbital period</b>	the amount of time it takes for a planet or exoplanet to make one full revolution around the Sun or a star, respectively
<b>planet</b>	a sphere moving in orbit around the Sun
<b>prediction</b>	a declaration or statement of what will happen based on reason and knowledge
<b>proportional</b>	when a variable is related to another quantity; such as a ratio
<b>scale</b>	a comparative relation between objects such as size or distance
<b>speed</b>	distance traveled over time
<b>star mass</b>	the amount of matter contained within a star
<b>transit</b>	the passage of a planet, exoplanet, moon, or asteroid across the face or disk of a star or other planetary body

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## 4.0 Procedure

### PRIOR KNOWLEDGE & SKILLS

- A. Arrangement of the Solar System
- B. Planet Names
- C. Square Roots
- D. Cube Roots
- E. Solving Polynomials

### PREPARATION

- A. Visit <https://infiniscope.org/lesson/celestial-jukebox/> for access to the digital learning experience and additional resources.
- B. PRINT THE FOLLOWING:
  - Learner **Worksheets (A)** – 1 per small group
- C. DOWNLOAD:
  - NASA Eyes on Exoplanets App (<https://eyes.nasa.gov/eyes-on-exoplanets.html>)

### STEP 1: ENGAGE (10-15 minutes)

#### Introduce Exoplanets and Elicit Prior Knowledge of Discovery

- A. Have students open the NASA *Eyes on Exoplanets* app and allow them 5-10 minutes to explore depending on their level of engagement.
- B. Facilitate Q&A with learners and record their responses to revisit:
  - 1. *How do scientists find these exoplanets?*
    - i. Responses will vary. Learners may have no idea or refer to powerful telescopes.
  - 2. *Once they've found these exoplanets, how do they know the distances these exoplanets are from the star they orbit?*
    - i. Responses will vary. Learners may have no idea or refer to scientists don't know.
- C. Say "These are all interesting ideas on how scientists discover and learn about these exoplanets. Let's find out!" Explain they will be using a digital simulation to explore the discovery methods of exoplanets.

### STEP 2: EXPLORE (~ 20 minutes)

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## Celestial Jukebox Exploratory Activity

- A. Hand out or assign computers and ask learners to access the Where are the small worlds? digital learning experience at <https://infiniscope.org/> and choose “**Explore**” to launch the experience.

**🍏 Educator Tip:** If learners seem to be stuck in the activity, it isn’t responding in a way that seems correct, or if an error occurs, click the “Restart” button located in the upper right corner of the screen. “Restart” will clear all of their progress and bring them back to the start screen. Hitting the browser’s “Refresh” or “Back” button will not restart the activity. If restarting still does not correct the error, please submit an error report using the “Report an Issue” button.

**🍏 Educator Tip:** Learners should never hit the browser’s “Refresh” or “Back” button. This will break their experience.

**🍏 Educator Tip:** If you would like to analyze learner interactions in this activity, you can sign up to join the **Infiniscope Teaching Network** (<https://infiniscope.org/join/>) and enroll your group into the activity. By enrolling, you will gain access to the analytics of the activity by learner to see how they progressed through the activity. You also have the ability to adopt the activity and adapt it to the specific needs of your classroom, school, or community.

**🕒 Time Management Tip:** Should you run out of time for learners to complete this activity there are a couple of options.

- **Option 1:** If learners are enrolled in the class through the Infiniscope Teaching Network, they can log in at home or at school at another time and pick up where they left off.
- **Option 2:** If learners are NOT enrolled in the class through the Infiniscope Teaching Network, they can restart the activity at home and complete at their own pace.

## STEP 3: EXPLAIN (~ 0 minutes)

### Check for Understanding

- A. Questions are embedded within the experience to verify learners are connecting their activities to key concepts. If you have time at the conclusion of their exploration, you can ask these questions again to affirm their understanding.
1. The farther a planet is from a star the [                      ] the tones occur.
    - i. Farther apart
  2. In summary, Kepler’s third law states that the cube of a planet’s [                      ] is proportional to the square of its [                      ]. This means that planets closer to the Sun have a [                      ] orbital period than planets farther from the Sun.

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- i. Distance
- ii. Period
- iii. Shorter

- Ⓢ **Misconception Alert:** It is important to point out to learners that a transit actually does not make a sound.

## STEP 4: ELABORATE (~ 10 - 45 minutes depending on option)

### Apply Kepler's Third Law

- Ⓢ **Misconception Alert:** Learners often have clear misconceptions regarding the appearance of these exoplanets. Publications typically show images of exoplanets when they have been discovered. It's important to inform learners that these images are nothing more than artistic renderings. Some renderings are based on small pieces of scientific info, but astronomers have never directly observed a planet around another star.
- A. What is the indicator for a transit if it isn't a sound. Use the images provided on (A) Transit Examples. Ask students to brainstorm what is measured during a transit if it isn't actually a sound.
1. *Students should conclude it is light. The graph demonstrates dips in light during a transit, similar to the dips produced in the sound graph.*

## STEP 5: EVALUATE (~ 5 minutes)

### Reevaluate Opening Questions

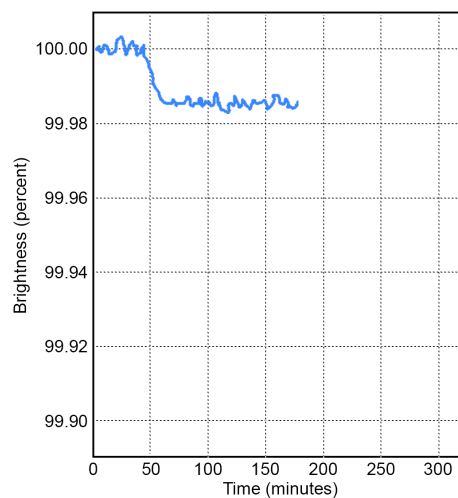
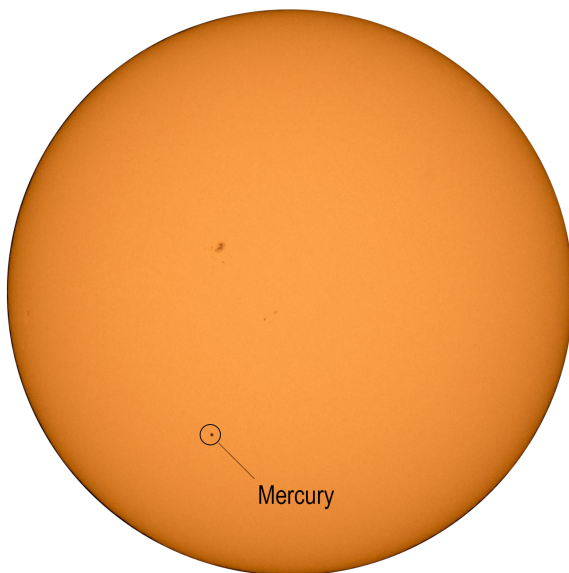
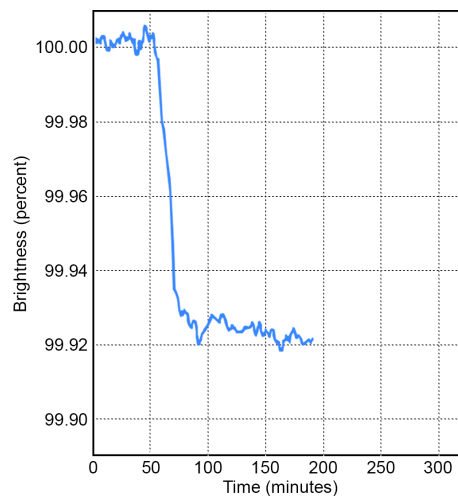
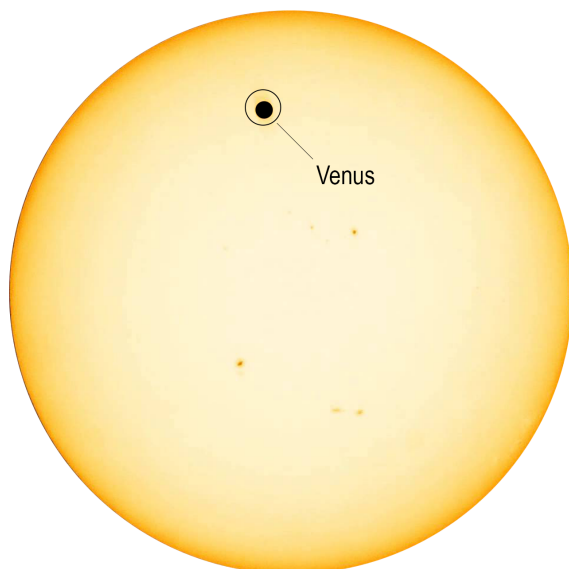
- A. Revisit the questions asked prior to exploration.
- B. Ask learners:
1. How do astronomers find these exoplanets? *Responses should discuss transits and dips in light (light curves).*
  2. Once they've found these exoplanets, how do they know the distances these exoplanets are from the star they orbit? *Responses should discuss using transits to plug in values for Kepler's third law and solve for distance.*

## 5.0 Extensions

1. Revisit the NASA [Eyes on Exoplanets](#) visualization.
2. Explore the NASA [Exoplanet Exploration](#) page.
3. Share the NASA graphic [The Lives of Stars](#).

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**(A) Transit Examples**

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