WHAT STUDENTS DO: Use a model to derive Kepler’s Third Law.

Students 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)

**IO1:** Develop and use a model of the solar system to derive and explain Kepler’s 3rd Law, then apply the equation to search for exoplanets in orbit around their stars.
1.0 About This Activity

How Students Learn: Science in the Classroom (Donovan & Bransford, 2005) advocates the use of a research-based instructional model for improving students’ grasp of central science concepts. Based on conceptual-change theory in science education, the 5E Instructional Model (BSCS, 2006) includes five steps for teaching and learning: Engage, Explore, Explain, Elaborate, and Evaluate. The Engage stage is used like a traditional warm-up to pique student curiosity, interest, and other motivation-related behaviors and to assess students’ prior knowledge. The Explore step allows students to deepen their understanding and challenges existing preconceptions and misconceptions, offering alternative explanations that help them form new schemata. In Explain, students communicate what they have learned, illustrating initial conceptual change. The Elaborate phase gives students the opportunity to apply their newfound knowledge to novel situations and supports the reinforcement of new schemata or its transfer. Finally, the Evaluate stage serves as a time for students’ own formative assessment, as well as for educators’ diagnosis of areas of confusion and differentiation of further instruction. The 5E stages can be cyclical and iterative.
2.0 Instructional Objectives, Learning Outcomes, Standards, & Rubrics

Visit https://infiniscope.org/lesson/celestial-jukebox/ for access to the digital learning experience, lesson plans, standards alignment documents, and additional resources.

Instructional objectives and learning outcomes are aligned with

- Achieve Inc.’s, *Next Generation Science Standards (NGSS)*
- National Governors Association Center for Best Practices (NGA Center) and Council of Chief State School Officers (CCSSO)’s, *Common Core State Standards for Mathematics*

The following chart provides details on alignment among the core and component NGSS questions, instructional objectives, learning outcomes, and educational standards.

- Your **instructional objectives (IO)** for this lesson align with the 21st Century Skills.
- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO)**, also aligned with 21st Century Skills.
- You will know the level to which your students have achieved the learning outcomes by using the suggested **rubrics**.

**Quick View of Standards Alignment:**

This alignment document provides full details of the way in which instructional objectives, learning outcomes, 5E activity procedures, and rubric assessments were derived through, and align with the 21st Century Skills. For convenience, a quick view follows:
**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

<table>
<thead>
<tr>
<th>Instructional Objective</th>
<th>Learning Outcomes</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students will be able to</td>
<td>Students will demonstrate the measurable abilities</td>
<td>Communication Grade 12 Benchmark</td>
</tr>
<tr>
<td>IO1: Develop and use a model of the solar system to derive and explain Kepler’s 3rd Law, then apply the equation to search for exoplanets in orbit around their stars.</td>
<td>LO1a: Use a sound diagram to identify patterns that indicate the period of a planet in the solar system. LO1b: Determine the orbital distance of a planet needed to generate the pattern of sound in a given model. LO1c: Interpret components of a light curve searching for patterns of transiting objects. LO1d: Use a light curve to identify patterns that indicate the period of a planet in the solar system.</td>
<td></td>
</tr>
</tbody>
</table>

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3.0 Instructional Objective, NRC Framework, NGSS, Common Core, & 21st Century Skills Connections

The connections diagram is used to organize the instructional objective addressed in the lesson to establish where it will meet the Next Generation Science Standards, NRC Framework, Common Core Standards, and the 21st Century Skills and visually determine where there are overlaps in these documents. See NGSS Alignment Document, NRC Framework Alignment Document, and Common Core State Standards Alignment Document for details on their specific alignments.

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

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4.0 Evaluation/Assessment

Use the (N) Celestial Jukebox Alignment Rubric as a formative and summative assessment, allowing students to improve their work and learn from mistakes during class. The rubric evaluates the activities using the 21st Century Skills.

5.0 References

Achieve, Inc. (2013). Next generation science standards. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS.


You will know the level to which your students have achieved the **Learning Outcomes**, and thus the **Instructional Objective(s)**, by using the suggested **Rubrics** below.

### Partnership for 21st Century Skills

<table>
<thead>
<tr>
<th>Instructional Objective</th>
<th>21st Century Skill</th>
<th>Grade 8 Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>IO1: Develop and use a model of the solar system to derive and explain Kepler’s 3rd Law, then apply the equation to search for exoplanets in orbit around their stars.</td>
<td>Communication</td>
<td>Students can explain why mathematical equations and formulae are used as representations of scientific phenomena and as a means of communicating scientific ideas.</td>
</tr>
</tbody>
</table>
### CELESTIAL JUKEBOX


Related Rubrics for the Assessment of Learning Outcomes Associated with the Above Standard(s):

<table>
<thead>
<tr>
<th>Partnership for 21st Century Skills</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Communication</strong></td>
</tr>
<tr>
<td><strong>Expert</strong></td>
</tr>
<tr>
<td><strong>Proficient</strong></td>
</tr>
<tr>
<td><strong>Intermediate</strong></td>
</tr>
<tr>
<td><strong>Beginner</strong></td>
</tr>
</tbody>
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