Celestial Jukebox

High School Common Core State Standards Alignment

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)

Students will be able to

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.

This material is based upon work supported by NASA under cooperative agreement No. NNX16AD79A. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration. This lesson was prepared by Arizona State University’s Education Through eXploration (ETX) Center. Lesson formatting was adopted and adapted from Arizona State University’s Mars Education Program. The lesson and its’ associated materials may be photocopied and distributed freely for non-commercial purposes. Copyright 2016-2021.

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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/](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 Common Core State Standards.

- You will know that you have achieved these instructional objectives if students demonstrate the related **learning outcomes (LO)**, also aligned with the Common Core State Standards.

- 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 Common Core State Standards. 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>Students will address</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.</td>
<td>MATH STANDARDS:</td>
</tr>
<tr>
<td></td>
<td>LO1b: Determine the orbital distance of a planet needed to generate the pattern of sound in a given model.</td>
<td>Algebra</td>
</tr>
</tbody>
</table>
| | LO1c: Interpret components of a light curve searching for patterns of transiting objects. | • Creating Equations  
CCSS.MATH.CONTENT.HSA.CED.A.2  
CCSS.MATH.CONTENT.HSA.CED.A.4 |
| | LO1d: Use a light curve to identify patterns that indicate the period of a planet in the solar system. | • Reasoning with Equations and Inequalities  
CCSS.MATH.CONTENT.HSA.REI.B.4.B  
CCSS.MATH.CONTENT.HSA.REI.D.10 |

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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 21st Century Skills 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.
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 Common Core State Standards.

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.


### Common Core State Standards

<table>
<thead>
<tr>
<th>Instructional Objective</th>
<th>MATH STANDARDS (High School)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IO1:</td>
<td></td>
</tr>
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</table>
| **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.** | **Algebra – Creating Equations**  
CCSS.MATH.CONTENT.HSA.CED.A.2  
Create equations that describe numbers or relationships:  
Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.  
  
CCSS.MATH.CONTENT.HSA.CED.A.4  
Create equations that describe numbers or relationships:  
Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm’s law $V = IR$ to highlight resistance $R$.  
  
**Algebra - Reasoning with Equations and Inequalities**  
CCSS.MATH.CONTENT.HSA.REI.B.4.B  
Solve equations and inequalities in one variable  
b. Solve quadratic equations by inspection (e.g., for $x^2 = 49$), taking square roots, completing the square, the quadratic formula and factoring, as appropriate to the initial form of the equation. Recognize when the quadratic formula gives complex solutions and write them as $a \pm bi$ for real numbers $a$ and $b$.  
  
CCSS.MATH.CONTENT.HSA.REI.D.10  
Represent and solve equations and inequalities graphically  
Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line). |
# (N) Teacher Resource. Celestial Jukebox Common Core State Standards Alignment Rubric

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

**Common Core State Standards**

<table>
<thead>
<tr>
<th>Expert</th>
<th>Proficient</th>
<th>Intermediate</th>
<th>Beginner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correctly solves for period and distance of a planet using the equation and the graphical representation for Kepler’s Third Law.</td>
<td>Correctly solves for period and distance of a planet using the equation or the graphical representation for Kepler’s Third Law.</td>
<td>Correctly solves for period or distance of a planet using the equation or the graphical representation for Kepler’s Third Law.</td>
<td>Solves for period and distance without taking the root of a variable.</td>
</tr>
</tbody>
</table>

**CCSS.MATH.CONTENT.HSA.CED.A.2**

Correctly solves for period and distance of a planet using the equation and the graphical representation for Kepler’s Third Law.

**CCSS.MATH.CONTENT.HSA.CED.A.4**

Correctly solves for period and distance of a planet using the equation or the graphical representation for Kepler’s Third Law.

**CCSS.MATH.CONTENT.HSA.REI.B.4.B**

Correctly solves for period or distance of a planet using the equation or the graphical representation for Kepler’s Third Law.

**CCSS.MATH.CONTENT.HSA.REI.D.10**

Solves for period and distance without taking the root of a variable.