



# celestial jukebox

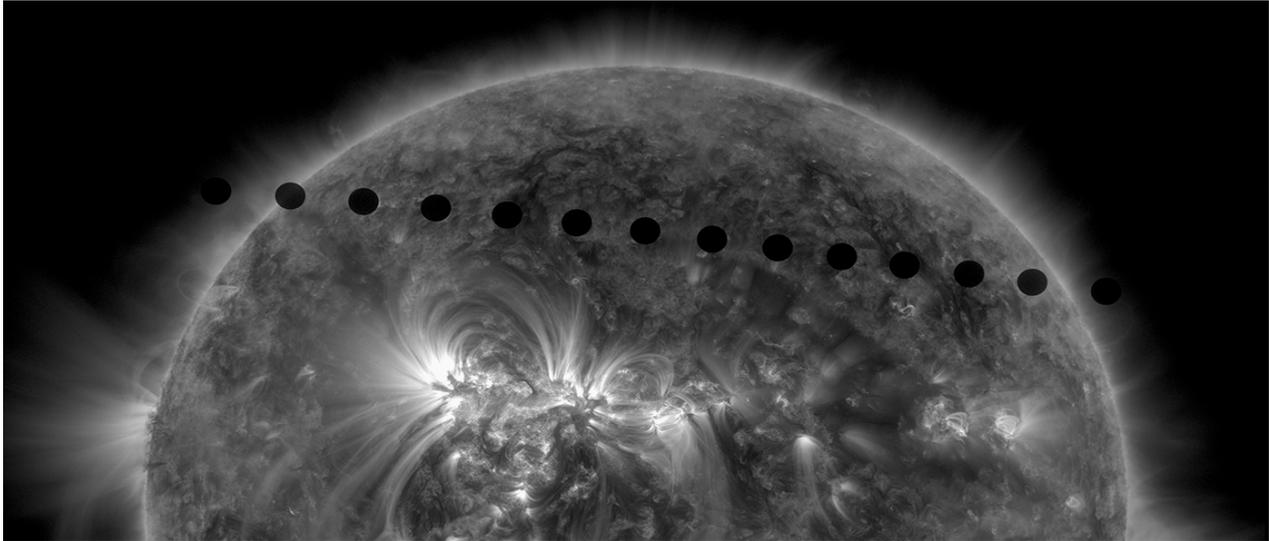






## Celestial Jukebox

### 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.**

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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.

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## 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 Research Council's, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*
- National Governors Association Center for Best Practices (NGA Center) and Council of Chief State School Officers (CCSSO)'s, *Common Core State Standards for Mathematics*
- Partnership for 21<sup>st</sup> Century Skills, *A Framework for 21<sup>st</sup> Century Learning*

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:

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## 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

<b>Instructional Objective</b> <i>Students will be able to</i>	<b>Learning Outcomes</b> <i>Students will demonstrate the measurable abilities</i>	<b>Standards</b> <i>Students will address</i>
<p><b>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.</b></p>	<p><b>LO1a: Use a sound diagram to identify patterns that indicate the period of a planet in the solar system.</b></p> <p><b>LO1b: Determine the orbital distance of a planet needed to generate the pattern of sound in a given model.</b></p> <p><b>LO1c: Interpret components of a light curve searching for patterns of transiting objects.</b></p> <p><b>LO1d: Use a light curve to identify patterns that indicate the period of a planet in the solar system.</b></p>	<p><b>MATH STANDARDS:</b></p> <p><b>Algebra</b></p> <ul style="list-style-type: none"> <li>• <b>Creating Equations</b> CCSS.MATH.CONTENT.HSA.CED.A.2 CCSS.MATH.CONTENT.HSA.CED.A.4</li> <li>• <b>Reasoning with Equations and Inequalities</b> CCSS.MATH.CONTENT.HSA.REI.B.4.B CCSS.MATH.CONTENT.HSA.REI.D.10</li> </ul>

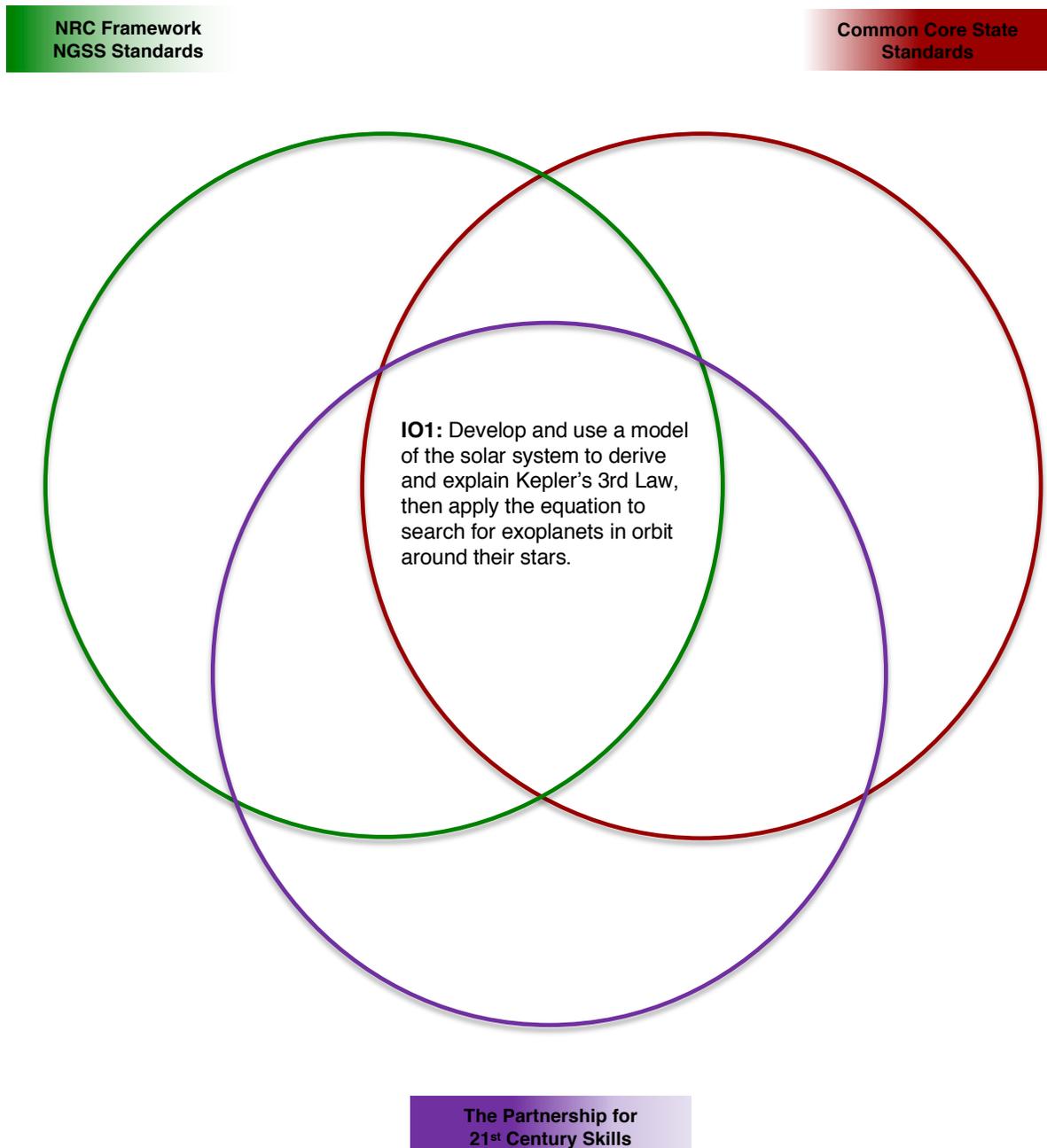
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### 3.0 Instructional Objective, NRC Framework, NGSS, Common Core, & 21<sup>st</sup> Century Skills Connections

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 21<sup>st</sup> Century Skills and visually determine where there are overlaps in these documents. See NGSS Alignment Document, NRC Framework Alignment Document, and 21<sup>st</sup> Century Skills Standards Alignment Document for details on their specific alignments.



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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 Common Core State Standards.

#### 5.0 References

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- Bybee, R., Taylor, J., Gardner, A., Van Scotter, P., Carson Powell, J., Westbrook, A., Landes, N. (2006) *The BSCS 5E instructional model: origins, effectiveness, and applications*. Colorado Springs: BSCS.
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- The Partnership for 21<sup>st</sup> Century Skills (2011). *A framework for 21<sup>st</sup> century learning*. Retrieved March 15, 2012 from <http://www.p21.org/>

**(M) Teacher Resource. Celestial Jukebox Common Core State Standards Alignment**

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.

 <b>Common Core State Standards</b>	
Instructional Objective	MATH STANDARDS (High School)
<b>IO1:</b> <b>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.</b>	<p><b>Algebra – Creating Equations</b>  <b>CCSS.MATH.CONTENT.HSA.CED.A.2</b>            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.</p> <p><b>CCSS.MATH.CONTENT.HSA.CED.A.4</b>            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 <math>V = IR</math> to highlight resistance <math>R</math>.</p> <p><b>Algebra - Reasoning with Equations and Inequalities</b>  <b>CCSS.MATH.CONTENT.HSA.REI.B.4.B</b>            Solve equations and inequalities in one variable            b. Solve quadratic equations by inspection (e.g., for <math>x^2 = 49</math>), 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 <math>a \pm bi</math> for real numbers <math>a</math> and <math>b</math>.</p> <p><b>CCSS.MATH.CONTENT.HSA.REI.D.10</b>            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).</p>

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**(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**

	Expert	Proficient	Intermediate	Beginner
CCSS.MATH.CONTENT.HSA.CED.A.2 CCSS.MATH.CONTENT.HSA.CED.A.4 CCSS.MATH.CONTENT.HSA.REI.B.4.B CCSS.MATH.CONTENT.HSA.REI.D.10	Correctly solves for period <u>and</u> distance of a planet using the equation <u>and</u> the graphical representation for Kepler's Third Law.	Correctly solves for period <u>and</u> distance of a planet using the equation <u>or</u> the graphical representation for Kepler's Third Law.	Correctly solves for period <u>or</u> distance of a planet using the equation <u>or</u> the graphical representation for Kepler's Third Law.	Solves for period <u>and</u> distance without taking the root of a variable.

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