




Celestial Sonification


Parts 1 and 2


Infiniscope

Learners use a model and data sonification to explore transits in our solar system. They derive Kepler's Third Law from the orbital distance and period data they collect. Then, learners apply Kepler's Third Law to an extrasolar system and the search for exoplanets.

[illegible]

Part 1



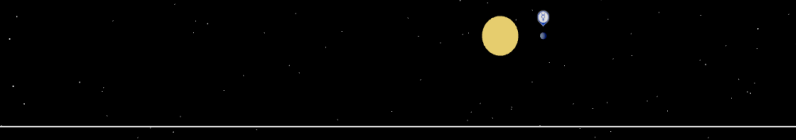


Orbital Period for One Planet

In this example, you'll see what a system looks like with just one planet orbiting a star. You'll be able to check out the pattern that emerges when we graph the brightness of the star's light, or **intensity**, against time.

Click on the button to see the system and make a curve of the planet's beats.

Graph the planet's beats



The diagram shows a yellow star and a blue planet in a circular orbit against a starry background. Below them is a graph with 'Intensity' on the vertical axis and 'Time' on the horizontal axis. The graph displays a series of periodic dips, representing the variation in light intensity as the planet orbits the star.

Summative Objective	Standards
Develop and use a model of the solar system to derive and explain Kepler's Third Law, then apply the equation to search for exoplanets in orbit around their stars.	<p>Science and Engineering Practices</p> <ul style="list-style-type: none"> Developing and Using Models Analyzing and Interpreting Data Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions <p>Disciplinary Core Ideas</p> <ul style="list-style-type: none"> ESS1.B: Earth and the Solar System <p>Crosscutting Concepts</p> <ul style="list-style-type: none"> Patterns Scale, Proportion, and Quantity

Lesson Specs




Grade Range

 Elementary	 Middle School	 High School	 College +
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NGSS Content Areas

 Life Sciences	 Earth and Space Sciences	 Physical Sciences
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Devices

 PC, Mac, Chromebook	 iPad, Android Tablet	 iPhone, Android Phone
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Browsers

 Chrome	 Edge	 Firefox	 Safari
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Key Details

Provided by Educator

Prep Time	~ 10 min
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✓ Prior Skills	<ul style="list-style-type: none"> <input type="checkbox"/> Use models <input type="checkbox"/> Read and interpret graphs <input type="checkbox"/> Recognize systems and their interactions <input type="checkbox"/> Communicate scientific information <input type="checkbox"/> Solve square roots and cube roots <input type="checkbox"/> Rearrange and solve algebraic equations
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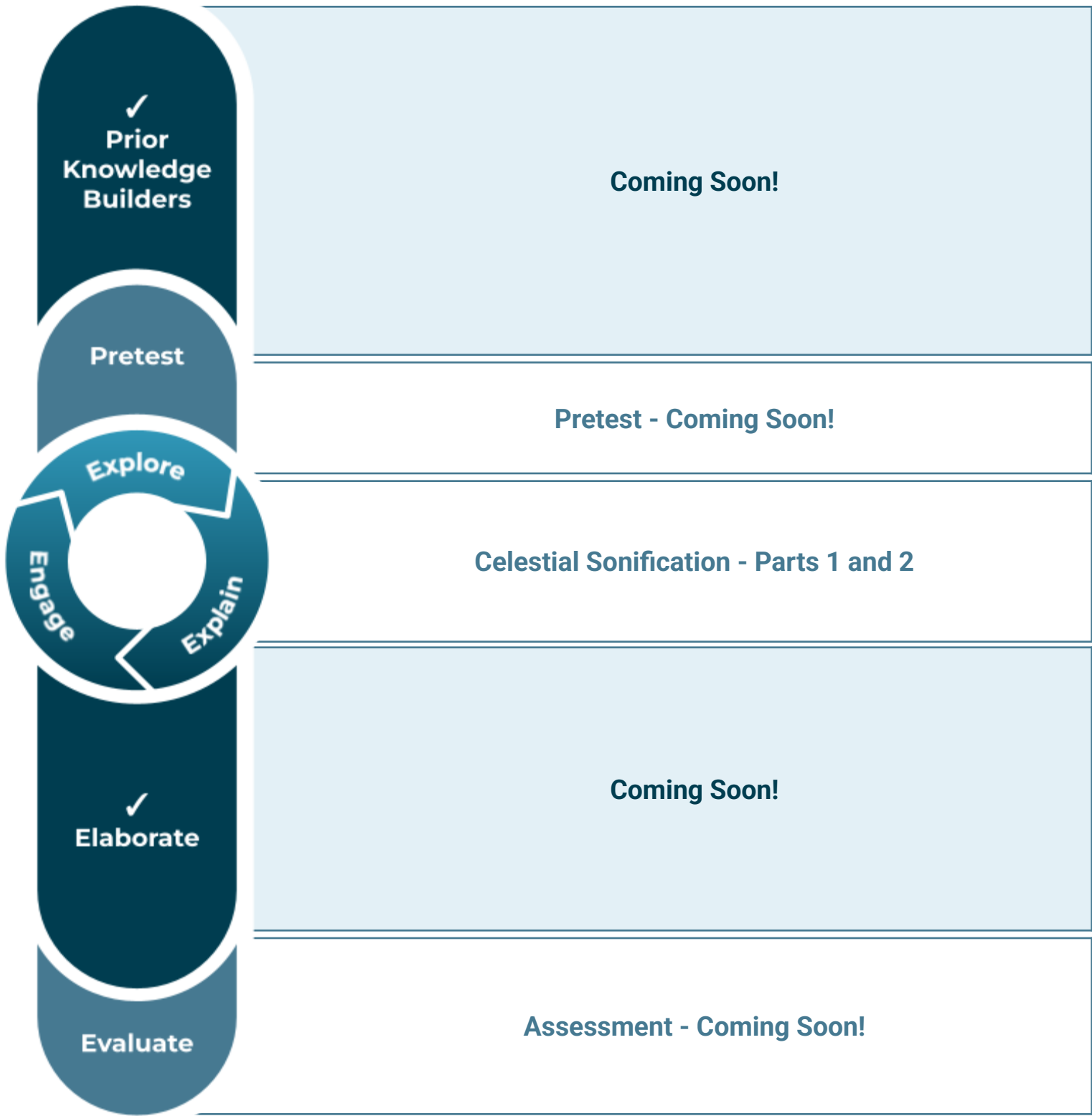
✓ Required Materials	<ul style="list-style-type: none"> <input type="checkbox"/> Computer or laptop <i>1 per student</i> <input type="checkbox"/> Access to Ethernet or wifi <input type="checkbox"/> Headphones
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Provided by Infiniscope

Lesson Time	~45 min total; two parts of 20-25 min each
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Skill Building	<ul style="list-style-type: none"> • Develop and use models • Recognize patterns • Analyze and interpret transit data • Solve algebraic equations for period and distance
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5E



Misconceptions

Below is a list of misconceptions that students commonly hold about planetary motion, transits, and Kepler's Third Law. Beneath each misconception is information for the instructor on how that misconception was addressed in the learning experience.



Misconception Alert

Misconception #1

Kepler's Third Law is unique to Earth–Sun orbits, and not universal for any planet-star system.

Strategy

Learners will apply Kepler's Third Law to other planets in our solar system as well as an extrasolar planetary system.

Misconception #2

A planet farther out from the Sun must move faster since the orbit is bigger.

Strategy

Learners will collect and analyze data to determine that planets farther from the Sun actually move slower. Since their orbits are bigger, it takes these planets longer to complete their orbits around the Sun.

Misconception #3

Every planet behaves differently.

Strategy

Learners will apply Kepler's Third Law mathematically and use graphs to see that all planets, despite seeming different, follow the same predictable pattern. When plotted, the data for every planet falls on the same curve.

Misconception #4

Transits are like solar eclipses. Venus or Mercury transits will dim the Sun noticeably like the Moon does.

Strategy

Learners will examine transit light curves and see that the drop in brightness of the Sun is very small. They will also watch a video that explains the amount of light from a star that is blocked during a transit is a very small percentage.

Vocabulary

Below is a list of vocabulary words, found in this learning experience, and their definitions. The definitions are provided here for the educator to use as they prepare students for the experience.

astronomical unit	a unit of measurement that represents the average distance between Earth and the Sun
distance	the length of a straight line between two points
exoplanet	a planet that orbits a star outside the solar system
exponent	a number representing how many times a value should be multiplied by itself
extrasolar systems	A system with a star other than the Sun at its center, with planets that orbit that star
habitable zone	the distance range from a star at which liquid water could exist on an orbiting planet's surface
Kepler's Third Law	states that the square of a planet's orbital period is directly proportional to the cube of its average orbital distance from the Sun
model	a simulation that helps explain natural and human-made systems and shows possible flaws
observations	specific details recorded to describe an object or phenomenon
orbital distance	the distance between a planet and its host star
orbital period	the time it takes for a planet to complete one orbit around its host star

planet	a sphere moving in orbit around the Sun
prediction	a declaration or statement of what will happen based on reason and knowledge
proportional	When a variable is related to another quantity; such as a ratio
sonification	the process that transfers data into sound. It can be used in many different ways to help identify patterns.
speed	distance traveled over time
star mass	the amount of matter contained within a star
transit	the passage of a planet, exoplanet, moon, or asteroid across the face or disk of a star or other planetary body

Next Generation Science Standards

Core Questions

Core Question	
<p>What is the universe, and what is Earth's place in it?</p> <p><i>NGSS Core Question: ESS1: Earth's Place in the Universe</i></p>	
Component Questions	Performance Expectations
<p>What are the predictable patterns caused by Earth's movement in the solar system?</p> <p>ESS1.B: Earth and the Solar System</p>	<p>HS-ESS1-4.</p> <p>Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.</p> <p>Clarification Statement</p> <p>Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.</p> <p>Assessment Boundary</p> <p>Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.</p>

NGSS Objectives

Objective		
<p>Develop and use a model of the solar system to derive and explain Kepler's Third Law, then apply the equation to search for exoplanets in orbit around their stars.</p>		
NGSS SEP	NGSS DCI	NGSS CCC
<p>Developing and Using Models</p> <p>Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.</p> <p>Analyzing and Interpreting Data</p> <p>Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.</p> <p>Using Mathematics and Computational Thinking</p> <p>Use mathematical, computational and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.</p> <p>Apply techniques of algebra and functions to represent and solve scientific and engineering problems.</p>	<p>ESS1.B: Earth and the Solar System</p> <p>Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)</p>	<p>Patterns</p> <p>Mathematical representations are needed to identify some patterns.</p> <p>Empirical evidence is needed to identify patterns.</p> <p>Scale, Proportion, and Quantity</p> <p>Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.</p> <p>Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).</p>

Constructing Explanation and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.