

Exoplanets

Novice

- The Sun is just another star, and many stars have planets around them.
- Two main methods for detecting planets around stars is when the planet blocks the light from the star (transit, like an eclipse), and from the star's wobble (Doppler).

Intermediate

- Use Kepler's Laws to calculate orbital properties of an exoplanet.
- The Habitable Zone is a region around a star where water would be liquid and thus an exoplanet could potentially support life.
- Additional methods for detecting planets around stars are taking a photo and seeing it (direct observation), gravity of a star and planet bending the light of a farther star (gravitational lensing), transit timing variations, transit duration variation, astrometry, and more.

Expert

- Calculate a planet's mass and radius from transit and RV data.
- 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.
- Strengths and weaknesses of the most commonly used methods.
- Calculations for the assorted methods.

Related NGSS

Grade Level	Student Performance Expectations
3-5	5-ESS1-2: Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.
MS	MS-ESS1-2 Analyze and interpret data to determine scale properties of objects in the solar system.
HS	HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Related CCSSM

Grade Level	Student Performance Expectations
3-5	<p>CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively. Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to <i>decontextualize</i>—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to <i>contextualize</i>, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.</p> <p>CCSS.MATH.PRACTICE.MP4 Model with mathematics. Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.</p> <p>CCSS.MATH.CONTENT.5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.</p>
MS	<p>CCSS.MATH.PRACTICE.MP4 Model with mathematics. Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a</p>

	<p>problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.</p> <p>CCSS.MATH.CONTENT.6.RP.A.1 Ratios and Proportional Relationships Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.</p> <p>CCSS.MATH.CONTENT.7.RP.A.2 Ratios and Proportional Relationships Recognize and represent proportional relationships between quantities.</p> <p>CCSS.MATH.CONTENT.6.EE.B.6 Use variables to represent numbers and write expressions when solving a real-world or mathematical problem; understand that a variable can represent an unknown number, or, depending on the purpose at hand, any number in a specified set.</p> <p>CCSS.MATH.CONTENT.7.EE.B.4 Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.</p>
HS	<p>CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively. Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to <i>decontextualize</i>—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to <i>contextualize</i>, to pause as needed during the manipulation process in order to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.</p> <p>CCSS.MATH.PRACTICE.MP4 Model with mathematics. Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the</p>

workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes.

CCSS.MATH.CONTENT.HSN.Q.A.1 Quantities

Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.MATH.CONTENT.HSN.Q.A.2 Quantities

Define appropriate quantities for the purpose of descriptive modeling.

CCSS.MATH.CONTENT.HSN.Q.A.3 Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

CCSS.MATH.CONTENT.HSA.SSE.A.1

Interpret expressions that represent a quantity in terms of its context.

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

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

Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations.