



# Conceptual Astronomy - Unit 2 - Origin of The Solar System

## Unit Focus

This unit is designed to enable students to independently analyze quantitative and qualitative data and use the scientific process to solve complex problems. The core Understandings center on the idea that the Sun's energy generation, stability, and influence—driven by nuclear fusion and energy transfer—are governed by fundamental physical laws. Students will also grasp that the formation, structure, and motion of all orbiting bodies, including phenomena like elliptical orbits and retrograde motion, are predictable consequences of universal laws of physics, such as gravity and conservation of momentum. Essential Questions driving this unit include: How do observations of the Sun inform our understanding of stellar internal workings and its impact on Earth? and What scientific evidence explains the origin, structure, and movements of planets in our solar system?

## Stage 1: Desired Results - Key Understandings

Standard(s)	Transfer	
<p><b>Next Generation Science Standards</b> Performance Expectations: High School Earth and Space Sciences</p> <ul style="list-style-type: none"> <li>Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation. (HS-ESS1-1)</li> <li>Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. (HSESS1-4)</li> </ul> <p>Disciplinary Core Ideas: High School</p> <ul style="list-style-type: none"> <li>Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) (HS.PS2.A. 2)</li> <li>Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) (HS.PS2.B.1)</li> <li>Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2- 4),(HS-PS2-5) (HS.PS2.B.2)</li> <li>The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HSESS1-1) (HS.ESS1.A.1)</li> <li>Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun.</li> </ul>	<p><i>Students will be able to independently use their learning to...</i></p> <p><b>T1</b> Analyze qualitative and quantitative data to interpret patterns, draw conclusions, and/or make predictions.</p> <p><b>T2</b> Use the scientific process to generate evidence that addresses the original questions.</p>	
	Meaning	
	Understanding(s)	Essential Question(s)
<p><i>Students will understand that...</i></p> <p><b>U1</b> The Sun's energy, stability, and influence on the solar system are governed by fundamental physical laws, particularly gravity, nuclear fusion, and energy transfer mechanisms.</p> <p><b>U2</b> The massive release of energy generated by nuclear fusion within a star's core is governed by the conservation of matter and energy, and this energy reaches planets through radiation and convection</p> <p><b>U3</b> The formation, structure, and motions of orbiting objects within the solar system are consequences of universal laws of gravity and conservation of momentum/angular momentum.</p> <p><b>U4</b> The composition of planets is fundamentally determined by the temperature gradient established by the central star during the solar system's formation and by a planet's orbital distance, mass, and internal heat.</p> <p><b>U5</b> Earth operates as a complex, interactive system where the transfer of heat provides the energy necessary to drive internal processes.</p>	<p><i>Students will keep considering...</i></p> <p><b>Q1</b> How have observations of the sun by astronomers expanded our understanding of the internal workings in stars?</p> <p><b>Q2</b> How can we use scientific evidence and reasoning to explain the sun's movements and its impact on Earth?</p> <p><b>Q3</b> What can the study of the sun tell us about the origin, formation, and structure of Earth and other planets in our solar system?</p> <p><b>Q4</b> What scientific evidence can be used to help us understand the movements of the planets.</p>	

## Stage 1: Desired Results - Key Understandings

<p>Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4) (HS.ESS1.B.1)</p> <ul style="list-style-type: none"> <li>Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. (secondary to HS-ESS1-1) (HS.PS3.D.1)</li> </ul> <p>Cross Cutting Concepts: High School</p> <ul style="list-style-type: none"> <li>In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8) (HS.SPM.CC.2.1)</li> <li>Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) (HS.FI.CC.1.1)</li> <li>When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) (HS.FI.CC.3.1)</li> </ul>	<p><b>U6</b> Observed movements of celestial bodies, such as the elliptical nature of orbits and the phenomenon of retrograde motion, reveal that complex cosmic patterns are predictable results of relative motion and universal laws of physics.</p> <p><b>U7</b> Earth’s orbital configuration, particularly its axial tilt and eccentricity, combined with the continuous operation of internal heat transfer and the interaction of the four spheres establishes the narrow range of conditions necessary to sustain climate, weather, and life.</p>	
<b>Acquisition of Knowledge and Skill</b>		
<b>Knowledge</b>		<b>Skill(s)</b>
<p><b>Next Generation Science Standards (DCI)</b> Science: 9</p> <ul style="list-style-type: none"> <li>The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (ESS1.9.A1)</li> <li>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. (ESS1.9.B1)</li> <li>Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (PS1.9.A1)</li> <li>The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (PS1.9.A2)</li> </ul> <p><b>Madison Public Schools Profile of a Graduate</b></p> <ul style="list-style-type: none"> <li>Analyzing: Examining information/data/ evidence from multiple sources to identify possible underlying assumptions, patterns, and relationships in order to make inferences. (POG.1.2)</li> <li>Product Creation: Effectively use a medium to communicate important information. (POG.3.2)</li> </ul>	<p><i>Students will know...</i></p> <p><b>K1</b> The Sun is divided into discrete layers (Core, Radiation Zone, Convection Zone, Photosphere, Chromosphere, Corona, and Magnetosphere/Tachocline).</p> <p><b>K2</b> Nuclear fusion is the process in the Sun's core where 4 Hydrogen atoms (4H) combine to form 1 Helium atom (1He), releasing energy.</p> <p><b>K3</b> The three primary ways thermal energy is transferred are conduction, convection, and radiation</p> <p><b>K4</b> Plasma is a state of matter similar to gas, composed of charged particles (ions)</p> <p><b>K5</b> The energy released during fusion is described by Einstein’s equation <math>E=mc^2</math></p> <p><b>K6</b> The Corona is the outermost layer of the Sun that is anomalously hot</p> <p><b>K7</b> The Sun experiences differential rotation, where the equatorial region, as well as the inner and outer regions rotate at different speeds, generating powerful magnetic fields</p> <p><b>K8</b> Sunspots are dark blemishes on the Sun’s surface (photosphere) caused by magnetic fields suppressing the normal convection and heat transfer.</p> <p><b>K9</b> Solar activity follows a regular pattern called the sunspot cycle.</p> <p><b>K10</b> Earth formed from a cloud of gas and debris into a multilayered sphere orbiting around the Sun.</p>	<p><i>Students will be skilled at...</i></p> <p><b>S1</b> Develop and use a hierarchical model to illustrate the internal structure and atmospheric layers of the Sun, explaining how the flow and conversion of energy (nuclear fusion, radiation, and convection) and the effects of differential rotation (magnetic fields) generate observable phenomena on the solar surface and in the solar atmosphere.</p> <p><b>S2</b> Obtain and interpret solar data (sunspot counts, total solar irradiance, UV index); connect cause and effect between solar activity and Earth impacts (aurora, radio/GPS disruptions, climate inputs).</p> <p><b>S3</b> Use and critique models of solar system formation (nebular collapse, accretion, conservation of angular momentum, differentiation).</p> <p><b>S4</b> Model and explain retrograde motion with a heliocentric framework; compare to geocentric explanations using evidence.</p> <p><b>S5</b> Use mathematical/computational representations of orbits (Kepler’s laws): plot and interpret <math>P^2</math> vs <math>a^3</math>; make</p>

## Stage 1: Desired Results - Key Understandings

**K11** Earth's magnetic field deflects the charged particles of the solar wind, causing the visible phenomenon known as the Aurora when particles interact with the atmosphere.

**K12** The age and formation of the solar system are largely inferred by analyzing meteorites and carbonaceous chondrites.

**K13** Planetary composition (rocky vs. gaseous) is strongly influenced by the distance from the Sun during formation (temperature gradient), and a planet's subsequent ability to retain an atmosphere is governed by its surface gravity and internal heat.

**K14** Retrograde motion is the apparent backward movement of a planet, which is an optical illusion resulting from the relative orbital speeds of Earth and the observed planet.

**K15** The path of objects orbiting the Sun is an ellipse, and the Sun is not located in the center of the orbit.

**K16** A planet's orbital velocity is fastest when it is closest to the Sun and slowest when it is farthest away (Kepler's laws).

**K17** Vocabulary: Angular Momentum, Aphelion, Apparent Diameter, Asthenosphere, Aurora, Carbonaceous Chondrite, Chromosphere, Conduction, Convection, Convection Zone, Core, Corona, Crust, Differential Rotation,  $E=mc^2$ , Eclipse, Ellipse, Equinox, Fission, Fusion, Geocentric, Geology, Giant Impact Theory, Granules, Gravity, Heliocentric, Helium, Hydrogen, Inner Core, Iron core, Lithosphere, Magnetosphere, Mantle, Nebular Hypothesis, Orbit, Orbital Velocity, Outer Core, Perihelion, Photosphere, Planetesimal, Plasma, Prominence, Radiation, Radiation Zone, Random Walk, Retrograde Motion, Revolution, Rotation, Solar Flare, Solar Wind, Solstice, Spicules, Sunspot Cycle, Sunspots, Surface Gravity, Tachocline, Thermonuclear Fusion, Zircons.

predictions of period, distance, and orbital speed.

**S6** Develop and use models of Earth's rotation, tilt, and revolution to explain day/night, solar path, day length, time zones, and seasons.