TAMALPAIS UNION HIGH SCHOOL DISTRICT
Larkspur, California
Course of Study

Astronomy 1-2

1. Introduction

Astronomy is the study of the Universe and our place in it. Students in Astronomy learn how the Universe started, how it has evolved to be filled with galaxies, stars and planets, and the ultimate fate of the Universe. The study of Astronomy stokes our fundamental curiosity about the world we live in.

Astronomy is a year-long physical science elective. Students in astronomy utilize basic concepts of chemistry, physics, and earth science, as applied to the study of stars, galaxies, and history of the Universe. The course is divided into two semesters. The first focuses on the development and evolution of the solar system and the Universe, including Cosmology. The second semester focuses on the sun, and the formation and evolution of stars in the Milky Way. This Astronomy course, a physical science elective, is offered to upper grade levels after successful completion of Integrated Science 1-4. The option of concurrent enrollment for students enrolled in I.S. 3-4 is available with teacher recommendation. The course appeals to students who are interested in learning more physical science in addition to Chemistry and Physics, and also appeals to students who wish to learn more physical science but are reluctant to take Chemistry and Physics.

The field of Astronomy changes rapidly as we use increasingly advanced technology to gather more data and information about our universe. To that end, the curriculum for Astronomy is an ever-evolving entity that accommodates new or altered information.

2. **Prerequisite skills** and knowledge:

Astronomy is a 10-credit physical science course open to students who have successfully completed Integrated Science 1-4 or who are currently enrolled in Integrated Science 3-4 (with teacher recommendation).

3. **List of program goals/learning outcomes** to be met

HS-ESS1-1 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 in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]

HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]

HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: 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.]

HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]

4. **Proficiency scales** aligned with the program goals listed above

HS-ESS1-1 The Sun		
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 in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]		
Proficiency Scale		
4.0	**In addition to the 3.0 level criteria, the student:** • Understands the role that magnetism plays in creating the surface features of the sun.	
	3.5	**No major errors or omissions regarding 3.0 content and partial knowledge of the 4.0 content**
3.0	**In addition to the 2.0 level criteria, the student:** • Can describe how material from earlier stars that exploded as supernovas is recycled to form younger stars and their planetary systems. • Understands that the sun is a medium-sized star about halfway through its predicted life span of about 10 billion years. • Can explain the relationship between energy output and solar features	
	2.5	**No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content**
2.0	**The student:** • Can describe how atoms of each element emit and absorb characteristic frequencies of light, and nuclear transitions have distinctive gamma ray wavelengths. • Can identify the different features of the sun	
	1.5	**Partial knowledge of the 2.0 content but some knowledge of the 3.0 content**
1.0	**Partial knowledge of the 2.0 content, but not of the 3.0 content.**	
	0.5	**Limited knowledge of the 2.0 content but not of the 3.0 content**
0.0	**No understanding or skill demonstrated.**	

HS-ESS1-1 The Sun		
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 in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]		
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4.0	**In addition to the 3.0 level criteria, the student:** • Understands the role that magnetism plays in creating the surface features of the sun.	
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	0.5	**Limited knowledge of the 2.0 content but not of the 3.0 content**
0.0	**No understanding or skill demonstrated.**	

HS-ESS1-2 The Universe		
Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. [Clarification Statement: Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).]		
Proficiency Scale		
4.0	**In addition to the 3.0 level criteria, the student:** • Understands that the universe is constantly evolving, as are the components within that universe (galaxies, stars, solar systems) • Can predict both quantitatively and qualitatively the future of the universe.	
	3.5	**No major errors or omissions regarding 3.0 content and partial knowledge of the 4.0 content**
3.0	**In addition to the 2.0 level criteria, the student:** • Understands that the Big Bang theory is supported by observations of distant galaxies receding from our own. • Understands that the Big Bang theory is supported by of the measured composition of stars and nonstellar gases, and of the maps and spectra of the primordial radiation (cosmic microwave background) that still fills the universe. • Can explain that stars' radiation of visible light and other forms of energy can be measured and studied to develop explanations about the formation, age, and composition of the Universe. • Understands that the sun is just one of more than 200 billion stars in the Milky Way galaxy, and the Milky Way is just one of hundreds of billions of galaxies in the Universe.	
	2.5	**No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content**
2.0	**The student:** • Understands that the sun is but one of a vast number of stars in the Milky Way galaxy, which is one of a vast number of galaxies in the Universe. • Can describe that he Universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.	
	1.5	**Partial knowledge of the 2.0 content but some knowledge of the 3.0 content**
1.0	**Partial knowledge of the 2.0 content, but not of the 3.0 content.**	
	0.5	**Limited knowledge of the 2.0 content but not of the 3.0 content**
0.0	**No understanding or skill demonstrated.**	

HS-ESS1-3 Stars		
Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]		
Proficiency Scale		
4.0	**In addition to the 3.0 level criteria, the student:** • Can predict the life cycle of a star based on its starting mass.	
	3.5	**No major errors or omissions regarding 3.0 content and partial knowledge of the 4.0 content**
3.0	**In addition to the 2.0 level criteria, the student:** • Understands that nearly all observable matter in the universe is hydrogen or helium, which formed in the first minutes after the Big Bang. Elements other than these remnants of the Big Bang continue to form within the cores of stars. • Can explain how nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases the energy seen as starlight. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. • Understands that stars go through a sequence of developmental stages—they are formed; evolve in size, mass, and brightness; and eventually burn out. • Understands that the study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	
	2.5	**No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content**
2.0	**The student:** • Knows that the sun is a star that appears larger and brighter than other stars because it is closer. Stars range greatly in their size and distance from Earth. • Understands the life cycle of a medium mass star, like our sun (main sequence, red giant, white dwarf)	
	1.5	**Partial knowledge of the 2.0 content but some knowledge of the 3.0 content**
1.0	**Partial knowledge of the 2.0 content, but not of the 3.0 content.**	
	0.5	**Limited knowledge of the 2.0 content but not of the 3.0 content**
0.0	**No understanding or skill demonstrated.**	

HS-ESS1-4 Orbital Physics		
Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: 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.]		
Proficiency Scale		
4.0	**In addition to the 3.0 level criteria, the student:** • Can predict the motions of different bodies within the solar system based on their orbit paths.	
	3.5	**No major errors or omissions regarding 3.0 content and partial knowledge of the 4.0 content**
3.0	**In addition to the 2.0 level criteria, the student:** • Uses Kepler's laws to 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. • Demonstrates that cyclical changes in the shape of Earth's orbit around the sun, together with changes in the orientation of the planet's axis of rotation, both occurring over tens to hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on Earth. These phenomena cause cycles of ice ages and other gradual climate changes.	
	2.5	**No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content**
2.0	**The student:** • Knows that the earth and the moon, sun, and planets have predictable patterns of movement. • Can explain how gravity holds Earth in orbit around the sun, and it holds the moon in orbit around Earth. • Understands that Earth's spin axis is fixed in direction over the short term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. • Knows that patterns of the motion of the sun, moon, and stars in the sky can be observed, described, and predicted.	
	1.5	**Partial knowledge of the 2.0 content but some knowledge of the 3.0 content**
1.0	**Partial knowledge of the 2.0 content, but not of the 3.0 content.**	
	0.5	**Limited knowledge of the 2.0 content but not of the 3.0 content**
0.0	**No understanding or skill demonstrated.**	

HS-ESS1-6 Solar Systems		
Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]		
Proficiency Scale		
4.0	**In addition to the 3.0 level criteria, the student:** • Can quantitatively compare the bodies within our solar system with regards to density, composition, etc. • Can create an accurate model of a solar system potentially found around a distant star.	
	3.5	**No major errors or omissions regarding 3.0 content and partial knowledge of the 4.0 content**
3.0	**In addition to the 2.0 level criteria, the student:** • Can describe how this system appears to have formed from a disk of dust and gas, drawn together by gravity. • Understands why planets are placed where they are in the solar system • Can use Earth features to understand geologic processes on other planets/moons	
	2.5	**No major errors or omissions regarding 2.0 content and partial knowledge of the 3.0 content**
2.0	**The student:** • Knows that the solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the sun and the moon, and the motion of the planets in the sky relative to the stars. • Understands the differences between terrestrial and Jovian planets and their placement in the solar system.	
	1.5	**Partial knowledge of the 2.0 content but some knowledge of the 3.0 content**
1.0	**Partial knowledge of the 2.0 content, but not of the 3.0 content.**	
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5. Suggested textbook, materials, equipment and resources

The primary text for the class was approved by the board in March, 2006:
Seeds, Foundations of Astronomy

6. Requirements satisfied

This course may be used as elective credit towards graduation but does not meet any specific graduation requirement. It meets the UC "g" elective requirement.

7. Appendices

I. Sample sequence of program goals

Fall Semester

HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]

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Spring Semester

HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.] [Assessment Boundary: 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.]

HS-ESS1-1 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 in the form of radiation. [Clarification Statement: Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries.] [Assessment Boundary: Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.]

HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements. [Clarification Statement: Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime.] [Assessment Boundary: Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.]

II. Sample unit of study – Inner Planets

<table>
<tr><th colspan="3">Stage 1 Desired Results</th></tr>
<tr><td rowspan="4">Established Goals

HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history. [Clarification Statement: Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.]</td><td colspan="2">Transfer</td></tr>
<tr><td colspan="2">Students will be able to independently use their learning to…

Create an accurate model of a solar system (star, planets, moons) potentially found around a distant star.</td></tr>
<tr><td colspan="2">Meaning</td></tr>
<tr><td>UNDERSTANDINGS
Students will understand that…

The gravity within a solar nebula creates a star and planets

There is a scientific reason why planets are placed where they are within a solar system

Geologic processes present on earth are similar to those present on the other planets and moons of the solar system

Terrestrial and gas planets have different composition, size, density, and location. Their physical characteristics can be traced back to the formation of the solar system.

The physical characteristics of the Earth, Moon, Solar System and Universe provide evidence supporting their formation theories (Moon formation from Earth collision with a large asteroid, nebula theory of formation of the solar system, big bang theory and universe expansion).</td><td>ESSENTIAL QUESTIONS
Students will keep considering…

How are solar systems around other stars similar/different from ours?

What planets can support life?</td></tr>
</table>

	Acquisition	
	Students will know… The four stages of planetary development The differences between terrestrial and Jovian planets and their placement within a solar system The solar system consists of the sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the sun by its gravitational pull on them The solar system is one of many in our galaxy. The solar system is located in an outer edge of the disc-shaped Milky Way galaxy, which spans 100,000 light years.	*Students will be skilled at…* Identifying a planet as terrestrial or Jovian. Identifying what types of features belong on terrestrial or Jovian planets.

Stage 2 - Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
		PERFORMANCE TASK(S): *Students will show that they really understand by evidence of…*
A/M	Correct sketching and ordering of planets with planetary data (size, density, moons, extent of exploration, etc.)	A "free choice" modeling activity where students use any materials they wish to create a scaled model of the solar system
T	1-4 scale assessment of answers.	Inner Planets Exam

A A T		OTHER EVIDENCE: *Students will show they have achieved Stage 1 goals by…* Completion of Reading Questions Completion of Planetary Video Guides Planetary "check ins"

Stage 3 – Learning Plan		
Code	*Pre-assessment* Toilet Paper Solar System Activity	
    A A A A M M A M T	LEARNING EVENTS *Student success at transfer, meaning, and acquisition depends on…* For each planet: (Earth, Mercury, Venus, Mars) Reading Questions Fun Facts Video Questions PowerPoint Notes Venus Activity Books Formation of the Solar System activity Extreme Planets Video Planetary Data Analysis Comparative Planetology research project	*Progress Monitoring* Planetary "check ins" where students are asked to compare/contrast two or more planets Inner Planets Test