Spearfish School District Curriculum Pacing Guide 2023-24

Astronomy

Science and Engineering Practices

- Developing and Using Models
- Planning and Carrying out Investigations
- Analyzing and Interpreting Data
- Argumentation from Evidence
- Scientific Explanations
- Mathematics and Computation

Cross Cutting Concepts

- Patterns
- Scale, Proportion, and Quantity
- Systems and System Models
- Cause and Effect
- Energy and Matter
- Stability and Change
- Structure and Function

Disciplinary Core Ideas

The Core ideas of the High School Physical Science standards include:

- Matter and Its Interactions
- Motion and Stability: Forces and Interactions
- Energy
- Waves and Their Applications in Technology for Information Transfer

The Core ideas of the High School Earth and Space Science standards include:

- Earth's Place in the Universe
- Earth's Systems

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9-12 Astronomy

Instructional Focus History of Astronomy	Focus Summary
1 **<u>The Cosmic Landscape</u>** 1. The Structure of the Universe 2. Measuring Distances 3. Forces Suggested Time Frame: **0.5 week**	The Universe is vast is scale, but can be organized by structure and distance, and can be described in terms of the fundamental physics principles of forces and motion.
2 **<u>The Cycles of the Sky</u>** 1. The Celestial Sphere 2. The Seasons 3. Eclipses Suggested Time Frame: **0.5 week**	Ancient people were very familiar with the night sky and developed timekeeping and calendars based on the apparent motion of celestial objects.
3 **<u>The Rise of Astronomy</u>** 1. Early Ideas: Classical Astronomy 2. The Planets 3. Astronomy in the Renaissance 4. The Birth of Astrophysics Suggested Time Frame: **1 week**	Human interest in the night sky transitions from curiosity and observation to a formal field of scientific endeavor and exploration.

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Instructional Focus	Dimensions Cross Cutting Concepts Disciplinary Core Ideas Science and Engineering Practices	Targeted Standards based Essential Skills & Concepts				Learning Goals / Essential Questions For Instructional Focus	Essential Vocabulary	Resources
		PS	LS	ESS	ED			

1 **The Cosmic Landscape** 1. The Structure of the Universe 2. Measuring Distances 3. Forces Suggested Time Frame: **0.5 week** **2** **The Cycles of the Sky** 1. The Celestial Sphere 2. The Seasons 3. Eclipses Suggested Time Frame: **0.5 week** **3** **The Rise of Astronomy** 1. Early Ideas: Classical Astronomy 2. The Planets 3. Astronomy in the Renaissance 4. The Birth of Astrophysics	☒Patterns ☒Scale, Proportion, and Quantity ☒Systems and System Models ☐Cause and Effect ☐Energy and Matter ☐Stability and Change ☐Structure and Function ☐ Matter and Its Interactions ☒Motion and Stability: Forces and Interactions ☒Energy ☐From Molecules to Organisms: Structures and Processes ☐Ecosystems: Interactions, Energy, and Dynamics ☒Earth's Place in the Universe ☐Earth's Systems	**1** HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system **2** HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **3** HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	**1** 1. What particles make up an atom? 2. What force holds the electrons to an atom's nucleus? 3. How big is an astronomical unit? 4. How is a light year defined? 5. What force holds different astronomical systems together? **6.** What other forces exist in nature? **2** 1. What is a constellation, and what is special about the zodiac constellations? 2. What causes the seasons? 3. How long does it take the Moon to go through a cycle of phases? 4. What is the difference between lunar and solar eclipses? **3** 1. What is meant by the phrase angular diameter? 2. What is parallax and how is it measured? 3. What is the difference between a heliocentric and geocentric model? 4. What are the three laws of planetary motion? 5. Describe the major astronomical contribution of the following: Aristotle, Eratosthenes, Ptolemy, Copernicus, Brahe, Kepler, Galileo, and Newton?	**1** Atom Electric charge Electric force Electron Neutrino Neutron Nucleus Astronomical unit Gravity Light year **2** Constellations Ecliptic Equinoxes Lunar eclipse Phases Precession Rotation axis Solar eclipse Solstices **3** Angular size Geocentric model Heliocentric model Kepler's three laws Parallax Retrograde motion	**1** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **2** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **3** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet

Instructional Focus	Dimensions Cross Cutting Concepts Disciplinary Core Ideas Science and Engineering Practices	Targeted Standards based Essential Skills & Concepts PS / LS / ESS / ED	Learning Goals / Essential Questions For Instructional Focus	Essential Vocabulary	Resources
Suggested Time Frame: **1 week**	☐Earth and Human Activity ☒Developing and Using Models ☐Planning and Carrying out Investigations ☒Analyzing and Interpreting Data ☒Argumentation from Evidence ☒Scientific Explanations ☐Mathematics and Computation				

Assessments: How do my students demonstrate their understanding and how do I measure their learning?

Formative: writing, worksheet, discussion, classroom activities
Summative: unit test, observation project

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Instructional Focus Fundamentals of Astronomy	Focus Summary
1 **Gravity and Motion** 1. Inertia 2. Orbital Motion and Gravity 3. Newton's 2nd Law of Motion 4. The Law of Gravity 5. Newton's 3rd Law of Motion 6. Measuring Mass Using Orbital Motion 7. Surface Gravity 8. Escape Velocity Suggested Time Frame: **1 week**	The work of Kepler and Newton allow astronomers to describe the nature of the Universe around us.
2 **Light and Atoms** 1. Properties of Light 2. The Electromagnetic Spectrum 3. The Nature of Matter and Heat 4. Radiation from Individual Atoms 5. Formation of a Spectrum 6. The Doppler Shift 7. Absorption in the Atmosphere Suggested Time Frame: **1 week**	Astronomers can use the dual nature of light to discern details about distant celestial objects.
3 **Telescopes** 1. Telescopes 2. Resolving Power 3. Detecting Light 4. Telescopes on the Ground and in Space 5. Observatories Suggested Time Frame: **1 week**	The use of reflection and refracting telescope, both ground-based and aloft, help astronomer view and explore distant celestial objects.

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Instructional Focus	Dimensions Cross Cutting Concepts Disciplinary Core Ideas Science and Engineering Practices	Targeted Standards based Essential Skills & Concepts				Learning Goals / Essential Questions For Instructional Focus	Essential Vocabulary	Resources
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1 **Gravity and Motion** 1. Inertia 2. Orbital Motion and Gravity 3. Newton's 2nd Law of Motion 4. The Law of Gravity 5. Newton's 3rd Law of Motion 6. Measuring Mass Using Orbital Motion 7. Surface Gravity 8. Escape Velocity Suggested Time Frame: **1 week** **2** **Light and Atoms** 1. Properties of Light 2. The Electromagnetic Spectrum 3. The Nature of Matter and Heat 4. Radiation from Individual Atoms 5. Formation of a Spectrum 6. The Doppler Shift 7. Absorption in the Atmosphere	☒Patterns ☒Scale, Proportion, and Quantity ☒Systems and System Models ☒Cause and Effect ☐Energy and Matter ☐Stability and Change ☐Structure and Function ☐ Matter and Its Interactions ☒Motion and Stability: Forces and Interactions ☒Energy ☐From Molecules to Organisms: Structures and Processes ☐Ecosystems: Interactions, Energy, and Dynamics ☒Earth's Place in the Universe ☐Earth's Systems	**1** HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **HS-PS2-1: Analyze data to support the claim that Newton's Second Law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration** **2** **HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** 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 that eventually reaches Earth in the form of radiation. **3** No applicable content standards	**1** 1. What is meant by inertia? 2. How does mass differ from weight? 3. Explain how inertia and gravity are both involved in an orbit. 4. What is Newton's Law of Gravity? 5. What does surface gravity measure? 6. What is meant by escape velocity? **2** 1. What makes elements different from each other? 2. Explain how the Doppler shift affects waves reflected by or emitted from a moving body. 3. Why is light called electromagnetic radiation? 4. What is a photon? How fast can a photon travel? 5. How are color and wavelength related? 6. What is meant by the electromagnetic spectrum? 7. How does the color of dense materials change with temperature? **3** 1. What is light gathering power, and how does it affect the ability to see faint objects? 2. What is the difference between a reflecting and a refracting telescope? 3. What is resolution of a telescope? What physical process limits it? 4. What is the purpose of an interferometer?	**1** Acceleration Escape velocity Inertia Law of gravity Mass Newton's 1st Law of Motion Newton's 2nd Law of Motion Newton's 3rd Law of Motion Surface gravity **2** Absorption Absorption-line spectrum Atmospheric window Blackbody Continuous spectrum Doppler shift Electromagnetic radiation Electromagnetic spectrum Electromagnetic wave Elements Emission Emission-line spectrum Photons Spectroscopy Wave-particle duality Wein's Law **3** Adaptive optics	**1** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **2** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **3** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet

Instructional Focus	Dimensions Cross Cutting Concepts Disciplinary Core Ideas Science and Engineering Practices	Targeted Standards based Essential Skills & Concepts PS / LS / ESS / ED	Learning Goals / Essential Questions For Instructional Focus	Essential Vocabulary	Resources
Suggested Time Frame: **1 week** **3** **Telescopes** 1. Telescopes 2. Resolving Power 3. Detecting Light 4. Telescopes on the Ground and in Space 5. Observatories Suggested Time Frame: **1 week**	☐Earth and Human Activity ☒Developing and Using Models ☐Planning and Carrying out Investigations ☐Analyzing and Interpreting Data ☒Argumentation from Evidence ☒Scientific Explanations ☐Mathematics and Computation		5. Why do astronomers put X-ray observatories in space rather than just on a high mountain? 6. What is meant by adaptive optics?	Atmospheric window Interferometer Light-gathering power Reflectors Refractors Resolving power Scintillation Seeing	

Assessments: How do my students demonstrate their understanding and how do I measure their learning?

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Summative: unit test, observation project

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Instructional Focus	Focus Summary
1 **<u>The Earth</u>** 1. The Earth as a Planet 2. The Earth's Interior 3. The Age of the Earth 4. Motions in Earth's Interior 5. The Earth's Magnetic Field 6. The Earth's Atmosphere 7. Motion of the Earth Suggested Time Frame: **1 week**	Astronomers use the characteristics and properties of the Earth as the basis of comparison for the other bodies in our Solar System and when determining and describing planets orbiting around other stars.
2 **<u>The Moon</u>** 1. The Surface of the Moon 2. Structure of the Moon 3. Orbit and Motions of the Moon 4. Origin and History of the Moon 5. Tides Suggested Time Frame: **1 week**	The Moon is our nearest neighbor in space, a natural satellite orbiting the Earth. It is a barren ball of rock, with about one-fourth the diameter of Earth, possessing no water, air, or life.
3 **<u>Survey of Solar Systems</u>** 1. Components of the Solar System 2. Formation of Planetary Systems 3. Other Planetary Systems Suggested Time Frame: **1 week**	The Solar System consists of the Sun and the bodies in its gravitational domain: the eight planets, dozens of dwarf planets, and swarms of moons, asteroids, and comets.
4 **<u>The Terrestrial Planets</u>** 1. Mercury 2. Venus 3. Mars 4. Why Are the Terrestrial Planets So Different? Suggested Time Frame: **1 week**	Terrestrial planers, as their name suggests, have a size and structure similar to Earth's. Within our Solar System, the planets Mercury, Venus, Earth, and Mars are terrestrial.

5 **The Outer Planets** 1. Jupiter 2. Saturn 3. Uranus 4. Neptune 5. Pluto and Beyond Suggested Time Frame: **1 week**	Beyond Mars, the Solar System is a realm of ice and frozen gas. In this frigid zone, far from the Sun, where solar heat is only a vestige of what we receive on Earth, the giant planets formed.
6 **Meteors, Asteroids, and Comets** 1. Meteors, Meteoroids, Meteorites 2. Asteroids 3. Comets 4. Giant Impacts Suggested Time Frame: **1 week**	Orbiting the Sun and scattered throughout the Solar System are numerous bodies much smaller than the planets—asteroids and comets. The asteroids are generally rocky objects in the inner Solar System. The comets are icy bodies and spend most of their time in the outer Solar System.
7 **The Sun, Our Star** 1. Size and Structure 2. How the Sun Works 3. Probing the Sun's Core 4. Solar Magnetic Activity 5. The Solar Cycle Suggested Time Frame: **1 week**	The Sun is a star, a dazzling, luminous ball of gas more than 100 times bigger in diameter than the Earth.

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Suggested time frame: **1** **<u>The Earth</u>** 1. The Earth as a Planet 2. The Earth's Interior 3. The Age of the Earth 4. Motions in Earth's Interior 5. The Earth's Magnetic Field 6. The Earth's Atmosphere 7. Motion of the Earth Time Frame: **1 week** **2** **<u>The Moon</u>** 1. The Surface of the Moon 2. Structure of the Moon 3. Orbit and Motions of the Moon 4. Origin and History of the Moon 5. Tides Time Frame: **1 week** **3** **<u>Survey of Solar Systems</u>**	☐Patterns ☒Scale, Proportion, and Quantity ☒Systems and System Models ☒Cause and Effect ☐Energy and Matter ☒Stability and Change ☒Structure and Function ☒ Matter and Its Interactions ☒Motion and Stability: Forces and Interactions ☐Energy ☐From Molecules to Organisms: Structures and Processes ☐Ecosystems: Interactions, Energy, and Dynamics	**1** <u>HS-ESS1-6:</u> 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. <u>HS-ESS2-1:</u> Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that cause changes to other Earth systems. **2** HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **3** <u>HS-ESS1-2:</u> 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. HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **4**	**1** 1. How do we know that the Earth has a liquid core? 2. What are two explanations that scientists offer for why the interior of the Earth is hot? 3. What is the relation between rising and sinking material in the Earth's interior and subduction and rifting? 4. What factors are thought to be responsible for the Earth's magnetic field? 5. How is the aurora related to the Earth's magnetic field? 6. Explain how the greenhouse works and how it relates to global warming. 7. What is precession? What are some of its possible consequences? **2** 1. How do maria differ from the highlands? 2. What formed the maria? 3. What are lunar rilles and rays? 4. Why does the Moon lack an atmosphere? 5. How do astronomers think the Moon formed? What evidence supports this theory? 6. Why is the Moon's surface cratered but the Earth's is not? 7. How are tides formed on the Earth? 8. How does the Moon rotate? Why does it spin in this manner? **3** 1. What properties, apart from position, distinguish the inner and outer planets? 2. What is the Oort Cloud, where is it located, and what kind of objects come from it? 3. How do we know the composition of Jupiter? 4. What is an interstellar cloud?	**1** Aurora Convection Coriolis effect Crust Differentiation Global warming Greenhouse effect Outer core Magnetic field Mantle Ozone Plate tectonics Precession Radioactive decay Radioactive elements Rifting Seismic waves Inner core Subduction **2** Craters Highlands Maria Rays Regolith Rilles Synchronous rotation Tidal braking Tidal bulge Tides **3** Accretion Asteroid Asteroid belt Bode's rule Comet	**1** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **2** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **3** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **4** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **5** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **6** • Textbook: "Explorations: An Introduction to Astronomy" • Video

1. Components of the Solar 2. System 3. Formation of Planetary Systems 4. Other Planetary Systems Time Frame: **1 week** **4** **The Terrestrial Planets** 1. Mercury 2. Venus 3. Mars 4. Why Are the Terrestrial Planets So Different? Suggested Time Frame: **1 week** **5** **The Outer Planets** 1. Jupiter 2. Saturn 3. Uranus 4. Neptune 5. Pluto and Beyond Time Frame: **1 week** **6** **Meteors, Asteroids, and Comets** 1. Meteors, Meteoroids, Meteorites	☒Developing and Using Models ☐Planning and Carrying out Investigations ☒Analyzing and Interpreting Data ☒Argumentation from Evidence ☒Scientific Explanations ☐Mathematics and Computation	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. HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **5** 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. HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **6** 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.	5. What is a solar nebula? What is its shape and why? 6. Describe the planetesimal theory of planet formation? 7. What observations of other solar systems have been made that support the solar nebula hypothesis? 8. What are two methods used to find exoplanets? **4** 1. What is peculiar about Mercury's rotation? What causes this oddity? 2. What is the dominant gas in Venus's atmosphere? How do astronomers know this? 3. Why is Venus so hot? 4. What are the Martian polar caps composed of? 5. What is the evidence that Mars once had running water on its surface? 6. What explanations have been offered for why the atmospheres of the terrestrial planets are so different? 7. How do astronomers explain why the Earth's atmosphere ended up with so little CO_2 compared with that of Mars and Venus? **5** 1. How do astronomers know what lies inside the outer planets? 2. What are the major gaseous substances that make up Jupiter and Saturn? 3. What is the interior structure of Jupiter and Saturn thought to be? 4. What are the rings of Saturn made of? How do astronomers know this? 5. What is unusual about Uranus's rotation axis? What might explain this peculiarity? 6. How do Uranus and Neptune differ from Jupiter in their interiors? 7. Why are the outer planets so large?	Condensation Dwarf planet Exoplanet Gravitational lensing Inner planets Interstellar cloud Interstellar grains Jovian planet Kuiper Belt Oort Cloud Outer planets Planetesimals Solar nebula Solar nebula theory Solar System Terrestrial planets **4** Photo dissociation Resonance Runaway greenhouse effect **5** Roche limit Shepherding satellites Trans-Neptunian object **6** Achondrite Asteroid Asteroid belt Carbonaceous chondrite Chondrite Coma Kuiper belt Meteor Meteor shower Meteorite Meteoroid	• Computer simulations • Internet **7** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet

Instructional Focus	Dimensions Cross Cutting Concepts Disciplinary Core Ideas Science and Engineering Practices	Targeted Standards based Essential Skills & Concepts PS / LS / ESS / ED	Learning Goals / Essential Questions For Instructional Focus	Essential Vocabulary	Resources
2. Asteroids 3. Comets 4. Giant Impacts Suggested Time Frame: **1 week** **7** **The Sun, Our Star** 1. Size and Structure 2. How the Sun Works 3. Probing the Sun's Core 4. Solar Magnetic Activity 5. The Solar Cycle Suggested Time Frame: **1 week**	☒Earth's Place in the Universe ☒Earth's Systems ☐Earth and Human Activity	HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. **7** 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 that eventually reaches Earth in the form of radiation. HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements	8. Where did Pluto and other TNOs form? How did they get to where they are today? **6** 1. What is the difference between a meteor, meteoroid, and meteorite? 2. Where are most asteroids found? 3. What do asteroids tell us about the formation of the Solar System? 4. What parts make up a comet? What are they made of? 5. Why are there two tails on some comets? What are they made of? 6. What is the Oort Cloud? What is the Kuiper Belt? 7. What creates meteor showers? **7** 1. How can we measure the Sun's size, mass, and temperature? 2. What is the Sun made of? How do we know this? 3. What holds the Sun together? 4. Why doesn't the Sun collapse? 5. How is solar energy generated? 6. What is meant by solar activity? 7. What role does magnetic activity play in solar activity? 8. Why do sunspots appear dark? 9. What is the solar cycle?	Oort Cloud Radiation pressure Solar wind Tail **7** Convection zone Cosmic ray Hydrostatic equilibrium Maunder minimum Neutrino Nuclear fusion Pressure Proton-proton chain Radiative zone Solar cycle Solar wind	

Assessments: How do my students demonstrate their understanding and how do I measure their learning?

Formative: writing, worksheet, discussion, classroom activities
Summative: unit test, observation project

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Instructional Focus	Focus Summary
1 **<u>Measuring the Properties of Stars</u>** 1. Measuring a Star's Distance 2. Measuring the Properties of Stars from Their Light 3. Spectra of Stars 4. Binary Stars 5. The H-R Diagram 6. Variable Stars 7. Finding Distance by the Method of Standard Candles Suggested Time Frame: **1 week**	Astronomers use several direct and indirect methods to determine the properties of stars classify them by similar properties.
2 **<u>Stellar Evolution</u>** 1. Overview of Stellar Evolution 2. Star Formation 3. Main-Sequence Stars 4. Giant Stars 5. Yellow Giants and Pulsating Stars 6. Death of Stars Like the Sun 7. Old Age of Massive Stars 8. History of Stellar Evolution Theories Suggested Time Frame: **1 week**	Stars' life spans, and the manner of their "death", are determined by their mass.
3 **<u>Stellar Remnants</u>** 1. White Dwarfs 2. Neutron Stars 3. Black Holes Suggested Time Frame: **1 week**	The properties of the stellar remains depend on the mass of the stars while they were active, and, in the act of "dying", stars can seed the universe with heavy elements.

4 **<u>The Milky Way Galaxy</u>** 1. Discovering the Milky Way 2. Overview of the Milky Way 3. Stars of the Milky Way 4. Gas and Dust in the Milky Way 5. Motion of Stars and Gas in the Milky Way 6. Measuring the Milky Way 7. The Galactic Center 8. Evolution of the Milky Way Suggested Time Frame: **1 week**	The Milky Way galaxy consists of a disk about 100,000 light-years in diameter embedded in a halo that extends out several times farther.
5 **<u>Galaxies</u>** 1. Discovering Galaxies 2. Measuring the Properties of Galaxies 3. Dark Matter 4. Active Galaxies 5. Probing Intergalactic Space 6. Galaxy Clusters Suggested Time Frame: **1 week**	Filling the depths of space are billions of galaxies; some resemble our home galaxy, the Milky Way, but most differ in shape, content, and size.
6 **<u>Cosmology</u>** 1. Observations of the Universe 2. Looking Back Toward the Beginning of Time 3. Evolution of the Universe 4. The Curvature of the Universe 5. The Inflationary Universe Suggested Time Frame: **1 week**	Cosmology is the study of the structure and evolution of the Universe as a whole. Evidence collected through a variety of sources gives clues about the origin and end of the known universe.

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Instructional Focus	Dimensions Cross Cutting Concepts Disciplinary Core Ideas Science and Engineering Practices	Targeted Standards based Essential Skills & Concepts				Learning Goals / Essential Questions For Instructional Focus	Essential Vocabulary	Resources
		PS	LS	ESS	ED			

Suggested time frame: **1** **Measuring the Properties of Stars** 1. Measuring a Star's Distance 2. Measuring the Properties of Stars from Their Light 3. Spectra of Stars 4. Binary Stars 5. The H-R Diagram 6. Variable Stars 7. Finding Distance by the Method of Standard Candles Suggested Time Frame: **1 week** **2** **Stellar Evolution** 1. Overview of Stellar Evolution 2. Star Formation 3. Main-Sequence Stars 4. Giant Stars 5. Yellow Giants and Pulsating Stars	☒Patterns ☒Scale, Proportion, and Quantity ☒Systems and System Models ☒Cause and Effect ☒Energy and Matter ☒Stability and Change ☒Structure and Function ☒ Matter and Its Interactions ☒Motion and Stability: Forces and Interactions ☒Energy ☐From Molecules to Organisms: Structures and Processes ☐Ecosystems: Interactions, Energy, and Dynamics ☒Earth's Place in the Universe ☐Earth's Systems	**1** 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 that eventually reaches Earth in the form of radiation. HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements **2** 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 that eventually reaches Earth in the form of radiation. HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements **3** 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 that eventually reaches Earth in the form of radiation. HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements **4**	**1** 1. How do astronomers triangulate a star's distance? 2. How is the parsec defined? How big is a parsec compared to a light year? 3. How do astronomers measure a star's temperature? 4. What is luminosity? What two characteristics of a star determine its luminosity? 5. What does a star's magnitude measure? 6. What are the stellar spectral types? 7. What is a binary star? 8. What is the H-R Diagram? 9. What is the main sequence? 10. How do we know that giant stars are big and dwarf stars are small? 11. What is the mass-luminosity relationship? 12. What is a variable star? 13. What is a standard candle and how is it used? **2** 1. What processes and forces determine the structure of stars? 2. Through what stages will the Sun evolve? Through what stages will a high-mass star evolve? 3. What is bipolar flow? 4. What is a T Tauri star? What is a Bok globule? 5. What determines when a star becomes a main sequence star? 6. How long do stars stay on the main sequence? 7. Why is it easier for a high-mass star than for a low-mass star to burn helium? 8. What is meant by a pulsating star? Why do stars pulsate? 9. What is a planetary nebula? **10.** What is a supernova explosion? **3**	**1** Binary star Dwarf Giant H-R diagram Luminosity Magnitude Main sequence Parallax Parsec Period Red giant Spectral type Variable star White dwarf Wein's Law **2** Bipolar flow Degenerate gas Helium flash Instability strip Interstellar cloud Main-sequence lifetime Nucleosynthesis Period-luminosity law Protostar Red giant Supernova Supernova remnant T Tauri star **3** Accretion disk Black dwarf Black hole Chandr4asekhar limit Compact star Curvature of space Degeneracy pressure Event horizon	**1** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **2** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **3** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **4** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **5** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet **6** • Textbook: "Explorations: An Introduction to Astronomy" • Video • Computer simulations • Internet

6. Death of Stars Like the Sun 7. Old Age of Massive Stars 8. History of Stellar Evolution Theories Suggested Time Frame: **1 week** **3** **Stellar Remnants** 1. White Dwarfs 2. Neutron Stars 3. Black Holes Suggested Time Frame: **1 week** **4** **The Milky Way Galaxy** 1. Discovering the Milky Way 2. Overview of the Milky Way 3. Stars of the Milky Way 4. Gas and Dust in the Milky Way 5. Motion of Stars and Gas in the Milky Way 6. Measuring the Milky Way 7. The Galactic Center	☐Developing and Using Models ☐Planning and Carrying out Investigations ☒Analyzing and Interpreting Data ☒Argumentation from Evidence ☒Scientific Explanations ☐Mathematics and Computation	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 that eventually reaches Earth in the form of radiation. HS-ESS1-3: Communicate scientific ideas about the way stars, over their life cycle, produce elements **5** 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. **6** 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.	1. How does a white dwarf form? 2. Can a white dwarf have a mass of 10 solar masses? What happens if a white dwarf increases in mass? 3. Explain what makes a nova occur. 4. What is a neutron star? 5. How do we observe neutron stars? 6. What creates the beams of radiation seen in pulsars? 7. What is nonthermal radiation? 8. What is a black hole? What properties do they have? 9. What is the Schwarzschild radius? 10. Can astronomer see black holes? Explain. **11.** What is Hawking radiation? **4** 1. How do we know our Galaxy is a flat disk? 2. How did Shapley deduce the Milky Way's size and the Sun's position in it? 3. How big in diameter is our Galaxy, and how much mass does it contain? 4. What are some differences between Population I and Population II stars? 5. How do we know interstellar matter exists? What different kinds and forms are there? 6. How does interstellar dust affect our observations of the Milky Way? 7. What evidence makes astronomers conclude the Milky Way has spiral arms? 8. How is star formation related to spiral arms? 9. How can we determine the Milky Way's diameter? Its mass? 10. What is meant by dark matter? Why do astronomers conclude the Milky Way may contain such matter? 11. What is the evidence for a black hole at the center of the Milky Way? **12.** What is meant by Population III stars? **5**	Exclusion principle Gravitational redshift Gravitational waves Hawking radiation Neutron star Nonthermal radiation Nova Pulsar Schwarzschild radius Type Ia supernova Type ii supernova White dwarf **4** Bulge Dark matter Dark nebula Disk Globular cluster Halo Interstellar matter Milky Way Open cluster Population I stars Population II stars Population III stars Reddening Scattering Spiral arm Star clusters **5** Active galaxy Barred spiral galaxy Dark matter Elliptical galaxy Galaxy Galaxy cluster Gravitational lens Hubble law Irregular galaxy	

8. Evolution of the Milky Way Suggested Time Frame: **1 week** **5** **<u>Galaxies</u>** 1. Discovering Galaxies 2. Measuring the Properties of Galaxies 3. Dark Matter 4. Active Galaxies 5. Probing Intergalactic Space 6. Galaxy Clusters Suggested Time Frame: **1 week** **6** **<u>Cosmology</u>** 1. Observations of the Universe 2. Looking Back Toward the Beginning of Time 3. Evolution of the Universe 4. The Curvature of the Universe 5. The Inflationary Universe Suggested Time Frame: **1 week**	☐Earth and Human Activity		1. What are the three main types of galaxies? How do the basic galaxy types differ in shape, stellar content, and interstellar matter? 2. Why do elliptical galaxies contain mostly Population II stars? 3. Explain several ways astronomers measure the distance to nearby galaxies. Why is it important to know the distance? 4. What is Hubble's Law? 5. Why does Hubble's Law not apply to nearby galaxies? 6. What are the three main types of active galaxies? 7. How might a large black hole form in a galaxy's core? What is a gravitational lens? 8. What is the Local Group? **9.** What is the Local supercluster? How many clusters might be in a supercluster and how big is one? **6** 1. Why do astronomers think the Universe is expanding? 2. What is meant by the age of the Universe? How old is it? 3. How is its age found? 4. What is Olber's Paradox? 5. Is our cosmic horizon the same as other galaxies? Why? 6. What is meant by a cosmic horizon? 7. What is the cosmic microwave background? What is its origin? 8. Why do astronomers think that the early Universe was hot and dense? 9. What determines whether the Universe will expand forever or recollapse? Explain what the critical density is. **10.** What is dark energy? What does its presence imply for the future of the Universe?	Local group Megaparsec Quasar Radio galaxy Recession velocity Redshift Seyfert galaxy Spiral galaxy Supercluster Supermassive black hole **6** Antimatter Big Bang Cosmic horizon Cosmic microwave background Cosmology Critical density Curvature of the Universe Dark energy Flat Universe Inflation Negative curvature Olber's Paradox Positive curvature	

Instructional Focus	Dimensions Cross Cutting Concepts Disciplinary Core Ideas Science and Engineering Practices	Targeted Standards based Essential Skills & Concepts				Learning Goals / Essential Questions For Instructional Focus	Essential Vocabulary	Resources
		PS	LS	ESS	ED			

Assessments: How do my students demonstrate their understanding and how do I measure their learning?

Formative: writing, worksheet, discussion, classroom activities
Summative: unit test, observation project