CONNECTICUT TECHNICAL EDUCATION AND CAREER SYSTEM

Grade 12

Astronomy

SC661 - 1 credit

Connecticut Technical High School System
39 Woodland Street
Hartford, Connecticut 06105

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CTECS - Vision of a Graduate

The Vision of a Graduate (VoG) at the Connecticut Technical Education and Career System (CTECS) embodies our commitment to preparing students for success in Connecticut's workforce.

Developed in collaboration with students, parents, staff, and employers, the VoG ensures that CTECS students are not only job-ready but also equipped to lead, innovate, and adapt in a dynamic world.

As educators, we are dedicated to developing these qualities by providing a comprehensive education that empowers our students to achieve their fullest potential and make meaningful contributions to society.

A Problem Solver	Work Ready
Problem solvers tackle challenges by identifying root causes of issues, brainstorming solutions, implementing effective strategies, and demonstrating adaptability. ➔ Engage students with open-ended, creative thinking tasks that require both conventional and innovative solutions. ➔ Facilitate group discussions and collaborative projects. ➔ Use real-world scenarios and hands-on activities. ➔ Highlight the importance of effort, persistence, and continuous learning. ➔ Provide regular feedback and encourage reflection.	*To be work-ready includes a combination of technical expertise, soft skills, and personal qualities that ensure a graduate can effectively contribute to the workplace from day one.* ➔ Set high standards for punctuality, responsibility, professionalism, and task completion. ➔ Use project-based learning and collaborative assignments. ➔ Emphasize clear written and verbal communication. ➔ Offer practical exercises like mock interviews and resume workshops. ➔ Integrate technology and teach digital literacy.
Respectful	**Skilled Socially**
Graduates who embody respectfulness emphasize the importance of treating others with dignity, valuing diversity, and fostering an inclusive and positive environment, both personally and professionally. ➔ Demonstrate personal, interpersonal, and professional skills. ➔ Show respect for diversity. ➔ Model respect through active listening and empathy. ➔ Set clear expectations for respectful interactions. ➔ Promote collaboration and group discussions. ➔ Celebrate respectful behavior. ➔ Address disrespect promptly and constructively.	*Graduates who are skilled socially are equipped to navigate social environments, build relationships, and contribute positively to their communities and workplaces.* ➔ Show awareness of global responsibility to others and the environment. ➔ Participate in community involvement. ➔ Design cooperative group projects and team activities ➔ Set expectations for respect and give regular feedback. ➔ Facilitate discussions on inclusivity, kindness, and respect. ➔ Model positive interactions and recognize strong social skills.
A Critical Thinker	**An Effective Communicator**

Critical thinkers approach problems systematically by analyzing, evaluating, and synthesizing information to make well-informed decisions and contribute to innovative solutions. ➔ Encourage critical thinking individually and collaboratively. ➔ Design lessons that challenge assumptions and explore diverse viewpoints. ➔ Use open-ended questions, rigorous activities, and cross-curricular projects. ➔ Integrate project-based learning and real-world problem-solving. ➔ Offer reflective opportunities like journaling and discussions. ➔ Cultivate an environment that values curiosity and inquiry.	*Effective communicators convey ideas, information, and emotions accurately and persuasively, fostering understanding and collaboration.* ➔ Communicate effectively using oral, written, visual, artistic, and technical modes. ➔ Include group discussions, presentations, and peer reviews. ➔ Promote active listening and thoughtful responses. ➔ Offer clear guidelines and constructive feedback. ➔ Stress clear, respectful, and purposeful communication.

CTECS Instructional Model

CTECS uses the Marzano Compendium to guide research-based instructional strategies that differentiate learning and promote access, engagement, and success for all students. Teachers apply these strategies to support diverse learners (including multilingual learners, students with disabilities, and students with varied academic or technical backgrounds) through scaffolds, modeling, guided practice, and multiple ways to participate and show understanding. This approach ensures every student can work toward proficiency in the Priority Standards and the competencies outlined in the CTECS Vision of a Graduate.

Curriculum Introduction

This curriculum document outlines the essential learning for this academic program and provides a clear structure for planning, instruction, and assessment. It includes the components required by NEASC Standard 2.2a, along with elements that reflect the unique nature of CTECS academic programs. The curriculum is organized to show what students learn in each course, how learning progresses across grade levels, and how instruction supports both technical skill development and the CTECS Vision of a Graduate.

Teachers should use this document to:

- Understand the overall structure and expectations of the course sequence
- Reference the Course Map to see the scope and sequence of Priority Standards
- Use the Priority Standards and Units of Study to guide daily, weekly, and cycle-based planning
- Integrate Big Ideas, Essential Questions, Skills/Learning Outcomes, vocabulary, and resources during lesson design
- Plan and implement formative assessments to monitor progress and guide instruction
- Prepare students for the District Summative Assessments, ensuring alignment with the Course Map
- Maintain consistency of instruction across campuses while adapting to student needs

Curriculum Components

Course Map

A Course Map serves as the scope and sequence for this course by outlining the progression of instructional units and the standards that guide teaching and assessment. While each campus will have individual student needs, cycle schedules, and industry-based opportunities, all instructors are expected to teach the standards outlined in the Course Map. Using the Course Map below, teachers will intentionally plan learning experiences that prepare students to meet the identified standards within the designated assessment windows.

Priority Standards (Units of Study)

Priority Standards identify the most essential learning in the trade program. They reflect the core technical competencies, safety practices, and industry-aligned skills that require the greatest instructional focus and appear on program assessments. In CTE programs, each Priority Standard also functions as a Unit of Study, because it includes the required components such as big ideas, essential questions, content topics, and skills/learning outcomes aligned to assessments.

Learning Outcomes

Learning outcomes are what students will know (Concepts) and be able to do (Skills). Concepts identify the major content topics within the Priority Standard (Unit of Study). They appear in the left column of the Learning Outcomes table and follow a similar coding structure as the Priority Standard. Skills are learning objectives that describe the measurable actions students must be able to perform to demonstrate proficiency.They appear in the right column of the Learning Outcomes table and show the progression of learning evidence in the Priority Standard.

Resources

Resources include the tools, equipment, texts, materials, and digital tools that support learning within each unit and reflect industry standards.

Assessment Practices

Teachers use ongoing formative assessments—such as questioning, checks for understanding, performance demonstrations, reflections, and teacher observation—to monitor progress, guide instruction, and support all learners in mastering the Priority Standards.

Vocabulary

Essential vocabulary includes the technical and academic terms students must understand and use accurately to engage in scientific learning and demonstrate proficiency on assessments. Vocabulary is foundational to safety, precision, and communication, and should be a primary initial focus within each unit and taught explicitly through modeling, demonstration, and repeated application.

Astronomy Philosophy

The Astronomy course is an elective program designed to provide an introduction to the study of the solar system, stars, galaxies, nebulae, and newly discovered celestial bodies. This academic curriculum ensures students develop an in-depth understanding of scientific content while building essential skills, such as communication, collaboration, inquiry, and problem-solving, that are central to their educational and professional lives. By raising student awareness of celestial objects, including their history, properties, interrelationships, and the origins of the universe, the course prepares learners to achieve their fullest potential and make meaningful contributions to society.

Aligned with the Next Generation Science Standards (NGSS), the program engages students in Scientific and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs) to investigate Earth's place in the universe and the physical laws governing motion and stability. Students gain rigorous academic and practical experience through hands-on laboratory and engineering activities, technology-based inquiry, and the active collection, analysis, and interpretation of student-generated data. This approach ensures that instruction focuses on core ideas such as Earth's systems, forces and interactions, and the application of waves in information transfer.

In accordance with NGSS philosophy, instruction is driven by observable phenomena and student-generated questions, challenging learners to use scientific knowledge to explain or predict real-world events occurring in the universe. The use of anchoring phenomena provides the context for students to engage in practices that develop the knowledge necessary to explain complex astronomical systems. Through a combination of research, online programs, and independent study, students prepare for a successful transition to post-secondary education or professional careers as work-ready graduates equipped to lead and innovate in a dynamic world.

INSTRUCTIONAL CONSIDERATIONS

Anchoring Phenomena: In accordance with NGSS philosophy, instructors will ***use observable phenomena and student-generated questions to drive instruction***. Natural phenomena are observable events that occur in the universe and that we can use our science knowledge to explain or predict; they are the context for the work of both the scientist and the engineer. The point of using phenomena to drive instruction is to help ALL students engage in practices to develop the knowledge necessary to explain or predict phenomena. Effective instruction, therefore, results in students being able to explain carefully selected and relevant phenomena by developing and applying the Learning Outcomes and crosscutting concepts (CCCs) through the use of the science and engineering practices (SEPs).

The textbook assigned for this curriculum is by McGraw-Hill Education. Alternatively, as the hard copy textbook is phased out, instructors can use “Astronomy 2e” through Rice University’s OpenStax. Teachers are ***not*** limited to using this textbook. Other textbooks that have resources that apply to the curriculum may be used as well.

Astronomy - Course Map

Semester 1

Semester 2

***Suggested pacing includes one standard per academic cycle**.

Unit 1: Foundations of Astronomy & Earth-Moon-Sun Dynamics

Unit 1 Anchoring Phenomenon: The Prehistoric Calendar. Exploring the precise alignment of ancient megalithic structures, such as Stonehenge, with specific celestial events like the summer solstice to drive inquiry into Earth's orbital patterns, axial tilt, and the historical evolution of astronomical observation from geocentric myths to modern laws of motion.

<table>
<tr><td colspan="2">Priority Standard 1: Origins of Astronomy</td></tr>
<tr><td colspan="2">Big Idea(s): Humanity's understanding of the cosmos has evolved from cultural beliefs and Earth-centered mystery into a predictable universe governed by universal laws of motion and gravity.</td></tr>
<tr><td colspan="2">Essential Question(s):
How has the field of Astronomy changed throughout the various historical ages?
How does the size of the Earth compare with the vast scale of the Universe?
Why is a foundational understanding of gravity and the Laws of Motion essential for astronomical research?</td></tr>
<tr><td>Students will Know:</td><td>As evidenced by:</td></tr>
<tr><td>1.1 Historical Eras

1.2 Astronomical Models

1.3 Scale Units

1.4 Newton's Laws of Motion

1.5 Gravity Factors</td><td>List technological advancements associated with specific historical periods to construct a timeline.
Compare and contrast Geocentric and Heliocentric theories.
Define and apply distance units to relative scales in the universe.
Explain how the Laws of Motion govern celestial mechanics.
Identify and calculate the factors that determine gravitational strength.</td></tr>
<tr><td colspan="2">Vocabulary: Ancient Astronomy, Astronomical Unit (AU), Geocentric Theory, Gravity, Heliocentric Theory, Light Year, Newton's Laws of Motion</td></tr>
<tr><td colspan="2">Resources:

• Texts: McGraw Hill Chapters 1 or 2 or Astronomy 2e Textbook by Rice University Open Stax.

• Digital/Web: NASA website; Windows2Universe (Archeoastronomy); NASA Rocket Science DIY Podcast.

• Media: DVD "Cosmic Voyage" (Powers of 10); DVD "Infinite Cosmos"; Discovery Education "Solar System Scale Model".

• Activities: Research project on ancient cultural beliefs; creating a scale model of the solar system.

SEP and CCC Connections:</td></tr>
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• SEP: Constructing Explanations and Designing Solutions. Students construct explanations regarding the relationship between universal laws of motion and the predictable nature of the cosmos. • CCC: Stability and Change. Students analyze how scientific advancements and the social need for navigation caused astronomical models to evolve from geocentric to heliocentric theories.

Priority Standard 2: Telescopes	
Big Idea(s): Advanced instrumentation and non-optical technologies allow astronomers to observe celestial phenomena across the entire electromagnetic spectrum, far beyond the limitations of human sight.	
Essential Question(s): ● Why are multiple types of telescopes (optical and non-optical) required for comprehensive astronomical research? ● How do environmental factors and the biological process of dark adaptation affect astronomical observations?	
Students will Know:	*As evidenced by:*
2.1 Optical Designs 2.2 Non-optical Categories 2.3 Dark Adaptation Process	● Compare and contrast the optical designs used by astronomers (Refracting, Reflecting). ● Select the appropriate telescope type based on the radiation being researched (Radio, X-ray, Gamma) ● Describe how the human eye reacts to darkness during astronomical observation.
Vocabulary: Dark Adaptation, Electromagnetic Radiation, Reflecting Telescope, Refracting Telescope	
Resources: • Texts: McGraw Hill Essay 1: Backyard Astronomy or Astronomy 2e Textbook by Rice University Open Stax. • Activities: Hands-on comparison of refracting and reflecting telescope components; eye reaction/dark adaptation demonstrations. **SEP and CCC Connections:** • SEP: Obtaining, Evaluating, and Communicating Information. Students evaluate the effectiveness of different telescope types (optical and non-optical) based on the specific wavelengths of electromagnetic radiation being researched. • CCC: Structure and Function. Students investigate how the physical structure of reflecting and refracting telescopes determines their function in light collection and magnification.	

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Priority Standard 3: Earth's Seasons	
Big Idea(s): The interaction of Earth's axial tilt and its orbital motion around the Sun creates predictable seasonal changes and determines the visibility of celestial patterns.	
Essential Question(s): ● What are the specific mechanics that cause Earth's seasonal cycles? ● Explain why different constellations and asterisms are visible at different times of the year.	
Students will Know:	*As evidenced by:*
3.1 Axial Tilt and Orbital Position 3.2 Solstice and Equinox Mechanics 3.3 Celestial Sphere Components 3.4 Zodiac Constellations and Asterisms	● Explain the cause of Earth's seasons and the change in daylight duration and angle. ● Define and differentiate between the two types of equinoxes and solstices. ● Identify the specific coordinates and landmarks used on the celestial sphere. ○ Identify the coordinates of the Celestial sphere, Right Ascension (RA) and Declination (DEC), Zenith, ecliptic, celestial equator, zodiac and celestial poles.. ● Differentiate between formal constellations and informal asterisms. ○ Explain the relationship between the Sun, Ecliptic and Zodiac Constellations. ○ Big Dipper and the Little Dipper, and constellations that are located within the Zodiac.
Vocabulary: Asterism, Axial Tilt, Celestial Sphere, Declination (DEC), Equinox, Right Ascension (RA), Solstice, Zenith	
Resources: • Texts: McGraw Hill Chapter 1 or Astronomy 2e Textbook by Rice University Open Stax.	

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• Digital/Web: McGraw Hill "Seasons Interactive". • Activities: Create a children's book about a specific constellation; modeling direct sunlight at different orbital locations. **SEP and CCC Connections:** • SEP: Developing and Using Models. Students use models of the celestial sphere and Earth's orbital path to explain the mechanics of seasonal change and constellation visibility. • CCC: Patterns. Students identify predictable patterns in the Earth-Sun relationship, such as solstices, equinoxes, and the changing duration of daylight.

Priority Standard 4: The Moon	
Big Idea(s): The Earth-Moon-Sun system is a dynamic relationship where gravitational forces and orbital motion govern phases, eclipses, and tidal behavior.	
Essential Question(s): ● How does the orbital motion of the Moon create the progression of lunar phases? ● Why does synchronous rotation ensure we only ever observe one side of the Moon? ● In what ways does the Moon's presence physically impact the Earth's rotation and tides? ● How is the composition of the Moon similar to Earth?	
Students will Know:	*As evidenced by:*
4.1 Lunar Phases 4.2 Synchronous Rotation 4.3 Eclipse Mechanics 4.4 Tidal Forces 4.5 Giant Impact Theory.	● Identify lunar phases based on the Moon's orbital position. ● Compare and contrast why the same side of the moon always faces Earth. ● Compare and contrast the alignment required for various eclipse types. ● Describe how the Moon creates tides and impacts Earth's rotation (Tidal Braking). ● Evaluate the composition of the Moon to support the impact formation
Vocabulary: Giant Impact Theory, Lunar Eclipse, Lunar Phase, Solar Eclipse, Synchronous Rotation, Tidal Braking	
Resources: • Texts: McGraw Hill Chapters 1, 6, and 7 or Astronomy 2e Textbook by Rice University Open Stax. • Digital/Web: McGraw Hill "Lunar Phases Interactive" and "Eclipse Interactive"; Discovery Education "Telling Time by the Light of the Moon". • Media: DVD "Origins"; Lunar and Planetary Institute (LPI) PowerPoints on moon formation and statistics. • Activities: Moon Phase Flip Book project. **SEP and CCC Connections:** • SEP: Developing and Using Models. Students develop models to illustrate the alignment of the Earth-Moon-Sun system required for various lunar phases and eclipses.	

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• CCC: Cause and Effect. Students analyze how the gravitational pull of the moon causes predictable physical effects on Earth, such as tidal cycles and tidal braking.

Unit 2: The Solar System

Unit 2 Anchoring Phenomenon: The Great Red Spot & Planetary Storms. Investigating the centuries-long stability of Jupiter's Great Red Spot in comparison to the dynamic atmospheric systems of Earth to drive inquiry into the diverse physical characteristics, habitability factors, and gravitational forces of Terrestrial and Jovian planets.

<table>
<tr><td colspan="2">Priority Standard 5: Planets of the Solar System</td></tr>
<tr><td colspan="2">Big Idea(s): The Solar System is a diverse ecosystem of celestial bodies, ranging from life-sustaining terrestrial planets to massive gas giants and small icy objects in the Kuiper Belt.</td></tr>
<tr><td colspan="2">Essential Question(s):
What specific combination of physical and chemical characteristics makes life possible on Earth?
How do the IAU criteria distinguish between a planet, a dwarf planet, and minor solar system bodies?</td></tr>
<tr><td>Students will Know:</td><td>As evidenced by:</td></tr>
<tr><td>5.1 Planetary Characteristics
5.2 IAU Status Criteria
5.3 Minor Solar System Bodies
5.4 Distribution Regions
5.5 Habitability Factors</td><td>Compare and contrast the physical properties of inner and outer planets (Terrestrial, Jovian).
Evaluate why objects like Pluto are classified as dwarf planets.
Compare and contrast the composition and behavior of small solar system bodies (Asteroids, Comets, Meteors).
Construct a diagram indicating the location of regions within the solar system (Asteroid Belt, Kuiper Belt, Oort Cloud).
List and explain the specific characteristics that make life possible on Earth.</td></tr>
<tr><td colspan="2">Vocabulary: Asteroid Belt, Dwarf Planet, Jovian Planet, Kuiper Belt, Oort Cloud, Terrestrial Planet</td></tr>
<tr><td colspan="2">Resources:
• Texts: McGraw Hill Chapter 7 or 8 or Astronomy 2e Textbook by Rice University Open Stax.
• Digital/Web: McGraw Hill "Gravity Variations Interactive"; NASA planetary data.
• Media: DVD "Origins".
• Activities: "Travel Brochure" for a chosen planet; Carol Ruel or Chris White's "Asteroid Lab".
SEP and CCC Connections:</td></tr>
</table>

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• SEP: Analyzing and Interpreting Data. Students evaluate planetary data (density, atmosphere, composition) to differentiate between terrestrial and Jovian planets and determine habitability factors. • CCC: Systems and System Models. Students treat the solar system as a complex system where the distribution of matter (planets, asteroid belts, Oort cloud) is governed by gravitational interactions.

Unit 3: Properties of Light & Stellar Evolution

Unit 3 Anchoring Phenomenon: The Invisible Rainbow. Using the diffraction and absorption lines of starlight (spectral "fingerprints") to drive questions on how astronomers use the electromagnetic spectrum to determine the exact chemical composition, temperature, and motion of stars millions of light-years away that we can never physically visit.

<table>
<tr><td colspan="2">Priority Standard 6: The Sun and Stellar Life Cycles</td></tr>
<tr><td colspan="2">Big Idea(s):
● Stars such as the sun have a life cycle.
● Stars are fueled by nuclear fusion and follow specific evolutionary paths, from birth to various stellar remnants, dictated by their initial mass.</td></tr>
<tr><td colspan="2">Essential Question(s):
● What is the internal structure of the Sun and how does it generate energy?
● How does a star's mass determine its eventual fate as a White Dwarf, Neutron Star, or Black Hole?</td></tr>
<tr><td>Students will Know:</td><td>As evidenced by:</td></tr>
<tr><td>6.1 Solar Structure
6.2 Nuclear Fusion Reactions
6.3 Solar Magnetic Activity
6.4 H-R Diagram Classifications
6.5 Stellar Evolution Stages
6.6 Stellar Remnants</td><td>● List and Diagram parts of solar bodies including internal and atmospheric layers.
● Describe the type of reaction that powers the Sun's energy release.
● Explain the causes and results of magnetic disturbances on solar surfaces.
● Identify the spectral class and magnitude of stars using the H-R diagram.
● Sequence the steps of a star from birth to death based on its mass.
● Compare and contrast the final stages of low-mass vs. high-mass stars.</td></tr>
<tr><td colspan="2">Vocabulary: Black Hole, H-R Diagram, Neutron Star, Nuclear Fusion, Solar Flare, Sunspot, White Dwarf</td></tr>
<tr><td colspan="2">Resources:
• Texts: McGraw Hill Chapters 7, 8, 11, or 12 or Astronomy 2e Textbook by Rice University Open Stax.
• Digital/Web: McGraw Hill "H-R Diagram," "Neutron Stars," and "Extra Solar Planets" Interactives.
• Media: DVD "Infinite Cosmos"; DVD "Origins".
• Activities: Analyzing H-R diagrams to classify stellar spectral classes.
SEP and CCC Connections:</td></tr>
</table>

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• SEP: Analyzing and Interpreting Data. Students use the Hertzsprung-Russell (H-R) diagram to classify stars and predict their evolutionary stages based on temperature and magnitude.
• CCC: Energy and Matter. Students investigate how nuclear fusion in the sun's core allows for the flow of energy and the creation of matter throughout a star's life cycle.

Priority Standard 7: Properties of Light	
Big Idea(s): The properties of the electromagnetic spectrum allow scientists to explore the universe beyond physical travel, using light to identify the composition, temperature, and motion of distant objects.	
Essential Question(s): ● What is the dual nature of light and how is it related to energy? ● How do astronomers use absorption and emission spectra to determine the chemical composition of celestial bodies? ● How does the Doppler effect allow us to measure the speed and direction of objects in space?	
Students will Know:	*As evidenced by:*
7.1 Wave-Particle Duality 7.2 Electromagnetic Spectrum Properties 7.3 Absorption and Emission Spectra 7.4 Blackbody Radiation Properties 7.5 Doppler Effect 7.6 Exoplanet Characteristics	● Define a photon and describe the wave-particle model. ● List parts of a wave and explain how wavelength relates to color and energy. ● Interpret spectral lines to identify the chemical composition of celestial bodies. ● Describe how blackbodies absorb and emit energy as a function of temperature. ● Analyze spectral shifts to determine the speed and direction of distant objects (Redshift, Blueshift). ● List the characteristics of an Exoplanet.
Vocabulary: Absorption Spectrum, Blackbody, Doppler Effect, Emission Spectrum, Photon, Wave-Particle Duality	
Resources: • Texts: McGraw Hill Chapter 3 or 4 or Astronomy 2e Textbook by Rice University Open Stax. • Digital/Web: University of Wisconsin Spectrum modules; CU Boulder "Waves/Particles" interactives; NASA "Imagers" (EMS/Radio); McGraw Hill "Blackbody Radiation" and "Doppler Shift" Interactives. • Activities: Flame Test Lab; Spectral Tube demonstrations; wave generation demonstrations with strings or springs. **SEP and CCC Connections:** • SEP: Analyzing and Interpreting Data. Students interpret spectral lines and Doppler shift data to determine the chemical composition and relative motion of distant celestial objects. • CCC: Cause and Effect. Students investigate how the interaction of light and matter (absorption/emission) provides observable evidence of an object's temperature and physical state.	

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Unit 4: Galaxies and Cosmology

Unit 4 Anchoring Phenomenon: The Redshift of the Deep Field. Analyzing deep-space imagery from the James Webb Space Telescope (JWST) showing the most distant galaxies ever observed to drive inquiry into galactic mergers, the role of Dark Matter, and the observable evidence for the continuous expansion of the universe following the Big Bang.

Priority Standard 8: Galaxies	
Big Idea(s): The universe is not a static collection of stars, but a dynamic ecosystem where galaxies grow, collide, and evolve, and are shaped by the presence of Dark Matter and the power of supermassive black holes.	
Essential Question(s): ● What are the primary classifications of galaxies and how do they differ structurally? ● What makes a galaxy "active," and why is the presence of Dark Matter necessary to explain galactic rotation?	
Students will Know:	*As evidenced by:*
8.1 Galaxy Classifications 8.2 Cannibalism and Mergers 8.3 Dark Matter and Active Galactic Nuclei (AGN) 8.4 Active Galaxy Types 8.5 Local Groups and Superclusters	● Sketch galaxy sub-classes and compare their structural properties (Spiral, Elliptical, Irregular). ● Define cannibalism and explain the results of galaxy collisions. ● Analyze discrepancies in observed rotation to evaluate the importance of Dark Matter. ● Compare and contrast different types of active galaxies (Quasars, Radio, Seyfert). ● Compare and contrast the scale of rich vs. poor galaxy clusters.
Vocabulary: Active Galactic Nucleus (AGN), Dark Matter, Galactic Cannibalism, Quasar, Supercluster	
Resources: • Texts: McGraw Hill Chapters 16 and 17 or Astronomy 2e Textbook by Rice University Open Stax. • Digital/Web: McGraw Hill "Dark Matter Interactive". • Media: Science Channel "Galaxies" series. • Activities: Sketching galactic subclasses (Spiral, Elliptical, Irregular). **SEP and CCC Connections:** • SEP: Constructing Explanations and Designing Solutions. Students construct explanations for galactic evolution and rotation discrepancies by analyzing the influence of Dark Matter and active galactic nuclei. • CCC: Scale, Proportion, and Quantity. Students compare the relative scales of the universe, from individual galaxies to massive superclusters.	

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<table>
<tr><td colspan="2">Priority Standard 9: The Universe</td></tr>
<tr><td colspan="2">Big Idea(s): The Big Bang theory provides a comprehensive scientific framework for the origin and continuous expansion of the entire universe over billions of years.</td></tr>
<tr><td colspan="2">Essential Question(s):
● How did the Universe begin according to the prevailing scientific theory?
● What evidence do we have that the Universe is currently expanding?
● How do scientists use Hubble’s Constant to estimate the age of the Universe?</td></tr>
<tr><td>Students will Know:</td><td>As evidenced by:</td></tr>
<tr><td>9.1 Big Bang Theory
9.2 Hubble’s Law and Universal Expansion
9.3 Hubble’s Constant and Universe Age
9.4 Cosmic Horizon</td><td>● Describe the prevailing scientific theory regarding the start of the universe.
● Interpret Hubble’s Law to explain the expansion of space.
● Calculate the estimated age of the universe using Hubble’s Constant.
● Define the "edge" of the observable universe.</td></tr>
<tr><td colspan="2">Vocabulary: Big Bang Theory, Cosmic Horizon, Hubble’s Constant, Hubble’s Law</td></tr>
<tr><td colspan="2">Resources:
• Texts: McGraw Hill Astronomy or Astronomy 2e Textbook by Rice University Open Stax.
• Digital/Web: McGraw Hill "Cosmology" interactive.
• Media: DVD "Origins".
• Activities: "Balloon Expansion" demonstration to model Hubble’s Law; calculating the age of the universe using Hubble’s Constant.
SEP and CCC Connections:
• SEP: Using Mathematics and Computational Thinking. Students use mathematical representations, such as Hubble’s Law and Hubble’s Constant, to calculate the age and expansion rate of the universe.
• CCC: Stability and Change. Students analyze the Big Bang theory as a model of the universe's transition from a point of infinite density to a continuously expanding system.</td></tr>
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Appendix A: Vocabulary

• Absorption Spectrum: A spectrum of electromagnetic radiation transmitted through a substance, showing dark lines due to the absorption of specific wavelengths.
• Active Galactic Nucleus (AGN): A compact region at the center of a galaxy that is significantly brighter than the rest of the galaxy.
• Ancient Astronomy: The study of celestial objects and phenomena by early civilizations using the unaided eye.
• Asterism: A recognizable pattern of stars that is not part of the 88 official constellations, such as the Big Dipper.
• Asteroid Belt: The region between the orbits of Mars and Jupiter where the majority of asteroids are located.
• Astronomical Unit (AU): A unit of measurement equal to the average distance between the Earth and the Sun.
• Axial Tilt: The angle between an object's rotational axis and its orbital axis, responsible for the Earth's seasonal cycles.
• Big Bang Theory: The prevailing scientific theory describing the origin of the universe from a point of infinite density and temperature.
• Black Hole: A region of space where gravity is so intense that nothing, including light, can escape.
• Blackbody: An ideal physical body that absorbs and emits all electromagnetic radiation that falls upon it.
• Celestial Sphere: An imaginary sphere of giant radius with Earth at its center, used by astronomers to map the positions of stars.
• Cosmic Horizon: The maximum distance from which light has had time to reach an observer since the beginning of the universe.
• Dark Adaptation: The biological process by which the human eye adjusts to low-light conditions for improved astronomical viewing.
• Dark Matter: Invisible matter that does not emit or reflect light but exerts a gravitational pull on visible stars and galaxies.
• Declination (DEC): The celestial coordinate equivalent to latitude on Earth.
• Doppler Effect: The change in frequency or wavelength of light in relation to an observer, seen as redshift or blueshift.
• Dwarf Planet: A celestial body that orbits the Sun and is round, but has not cleared the neighborhood around its orbit.
• Electromagnetic Radiation: Waves of energy, such as radio, visible light, and X-rays, that travel through space and provide data for non-optical telescopes.
• Emission Spectrum: A spectrum showing bright lines emitted by a source of radiation.
• Equinox: The two times each year when the Sun crosses the celestial equator and day and night are of approximately equal length.
• Galactic Cannibalism: The process where a large galaxy merges with a companion galaxy through gravitational interaction.
• Geocentric Theory: The historical, incorrect model of the universe that placed the Earth at the center.

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• Giant Impact Theory: The leading theory that the Moon formed from debris after a collision between Earth and a Mars-sized body.
• Gravity: The force of attraction between two objects determined by their mass and distance.
• Heliocentric Theory: The model of the solar system that correctly identifies the Sun as the center.
• H-R Diagram: A graph used to classify stars by showing the relationship between their temperature and magnitude.
• Hubble's Constant: A value used to calculate the age and rate of expansion of the universe.
• Hubble's Law: The observation that galaxies move away from Earth at speeds proportional to their distance.
• Jovian Planet: Large, gaseous outer planets, including Jupiter, Saturn, Uranus, and Neptune.
• Kuiper Belt: A region of the solar system beyond Neptune containing many small, icy bodies.
• Light Year: The distance that light travels in one vacuum year.
• Lunar Eclipse: An event where the Earth blocks sunlight from reaching the Moon.
• Lunar Phase: The appearance of the illuminated portion of the Moon as viewed from Earth.
• Neutron Star: The extremely dense, compact remains of a high-mass star following a supernova.
• Newton's Laws of Motion: Three physical laws that describe the relationship between a body and the forces acting on it.
• Nuclear Fusion: The reaction that powers stars, where lighter nuclei combine into heavier elements to release energy.
• Oort Cloud: A theoretical spherical shell of comets believed to surround the outermost reaches of the solar system.
• Photon: A particle representing a discrete quantum of light or other electromagnetic radiation.
• Quasar: An extremely luminous active galaxy powered by a supermassive black hole.
• Reflecting Telescope: An optical telescope that uses mirrors to gather and focus light.
• Refracting Telescope: An optical telescope that uses lenses to gather and focus light.
• Right Ascension (RA): The celestial coordinate equivalent to longitude on Earth.
• Solar Eclipse: An event where the Moon blocks the Sun's light from reaching Earth.
• Solar Flare: A sudden, intense eruption of radiation from the Sun's surface.
• Solstice: The two times each year when the Sun reaches its highest or lowest point in the sky at noon.
• Sunspot: A cooler, darker region on the Sun's surface caused by intense magnetic activity.
• Supercluster: A massive group containing multiple galaxy clusters.
• Synchronous Rotation: The phenomenon where the Moon rotates and revolves at the same rate, keeping one side always facing Earth.
• Terrestrial Planet: Small, rocky inner planets, including Mercury, Venus, Earth, and Mars.
• Tidal Braking: The slowing of Earth's rotation caused by the gravitational interaction with the Moon.
• Wave-Particle Duality: The concept that light exhibits properties of both waves and particles.
• White Dwarf: The small, dense core left behind after a low-mass star ceases nuclear fusion.
• Zenith: The point on the celestial sphere directly overhead an observer.