Course Title: Science of the Universe

Board Approved: October 2026

Unit 1: Early Astronomy - Modeling the Solar System	Time: 2-3 weeks

Academic Standards:

3.2.9-12.L: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces

3.3.9-12.D: Use mathematical or computational representations to predict the motion of orbiting objects

3.5.9-12.NN: Analyze the rate of technological and engineering development and predict future diffusion and adoption of new innovations and technologies

3.5.9-12.JJ: Identify and explain how the evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools, materials, and processes.

3.5.9-12.GG: Evaluate how technology and engineering have been powerful forces in reshaping the social, cultural, political, and landscapes throughout history.

3.5.9-12.KK: Relate how technological and engineering developments have been evolutionary, often the result of a series of refinements to basic inventions or technological knowledge.

Essential Content/Objectives: At the end of the unit, students will be able to:

- Describe observations that paved the way for geocentric model
- Explain the limitations of the Ptolemaic model in accounting for retrograde motion
- Identify key historical figures (e.g., Ptolemy, Copernicus, Kepler, Galileo, Newton) and their contributions to astronomy
- Compare geocentric and heliocentric models in terms of predictive power and simplicity
- Explain how empirical evidence (e.g., planetary motion, moon phases, telescope observations) led to the replacement of older models
- Identify and explain the impact of various technological advances such as the Quadrant, Astrolabe, and Telescope

Assessment:

- Formative Assessments
  - Daily Class Warm-Ups
  - Concept Maps of our Solar System
- Summative Assessments
  - Unit 1 Exam
- Ancient Astronomy Biography Presentations
  - Informative presentations regarding selected Astronomers
- Timeline
  - Ancient Astronomer/Discovery timeline
- Kepler's Law Lab

- Describe how Galileo and telescope observations - impact on models and society and how better technology led to more accurate and predictive models
- Relate the Historical and Culture Context of Astronomy as related to religion and society
- Explain the contributions of Babylonian, Jewish, Christian, Islamic, Egyptian, Greek, and Persian societies to astronomy
- Explain how astronomy influenced society in terms of navigation, agriculture, etc

Core Student Activities: Students will complete/participate in the following:

- Use paper or digital simulations (e.g., *PhET*, *NASA Eyes*, Stellarium) to recreate planetary positions using each model.
- Plot retrograde motion paths and determine which model better explains observations
- Construct and use a paper or cardboard astrolabe.
- Hold a structured debate or Socratic seminar: Was Galileo a scientist or a rebel?
- Build a chronological timeline from ancient Greece to Newton
- Use string, thumbtacks, and colored paper to physically model circular orbits, epicycles, and ellipses
- Design and test sundials.

Materials and Resources:

- Stellarium and Phet resources and chromebooks
- Graph paper, protractors, rulers, and compasses
- Cardstock
- Astrolabe templates

Instructional Methods:

- Direct Instruction and Guided Notes
    - Teacher-led instruction introduces major concepts, ancient astronomers, and models of the solar system.
    - Investigation into Kepler's three laws
- Class Jeopardy
    - Students will participate in a Jeopardy-based activity relative to the content learned in the unit

Extensions:

- Create a museum exhibit
- Planetarium Visit
- Planet or star chart

Remediation:

- Teacher prepared videos
    - Geocentrism vs. Heliocentrism
    - What is Astronomy?
    - Historical Models of the Solar System

○ Students complete guided notes and daily warm-ups to reinforce key ideas. ● Research and Presentation ○ Students research a selected ancient astronomer and their contributions to astronomy. ○ Students present their findings to the class. ● Timeline and Concept Mapping ○ Students organize major astronomers and discoveries chronologically. ○ Students create concept maps to show relationships between objects and ideas within the solar system. ● Laboratory Investigation ○ Students investigate Kepler's three laws using observations, data, and guided activities. ○ Students use evidence from the investigation to identify patterns in planetary motion.	○ Stellar Parallax ○ Epicycles and Axial Procession ○ Kepler's Three Laws

Unit 2: The Formation of the Earth	**Time: 2-3 weeks**

Academic Standards:

3.3.9-12.A Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the suns core to release energy in the form of radiation

3.3.9-12.F Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.

3.3.9-12.H Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.

3.3.9-12.G 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.

3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces

3.5.9-12.NN Analyze the rate of technological and engineering development and predict future diffusion and adoption of new innovations and technologies

3.5.9-12.PP Demonstrate the use of conceptual, graphical, virtual, mathematical, and physical modeling to identify conflicting considerations before the entire system is developed and to aid in design decision making.

3.5.9-12.JJ Identify and explain how the evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools, materials, and processes.

3.5.9-12.GG Evaluate how technology and engineering have been powerful forces in reshaping the social, cultural, political, and landscapes throughout history.

3.5.9-12.KK Relate how technological and engineering developments have been evolutionary, often the result of a series of refinements to basic inventions or technological knowledge.

Essential Content/Objective: At the end of the unit, students will be able to:

- Describe Earth's formation and internal structure via planetary accretion including its compositional layers - core, mantle, crust, etc
- Validate our theories of earth's formation with seismic data, radiometric contributions, and the evolution of modeling
- Describe how plate tectonics and the structure of the earth contribute and explain:
    - Earthquakes, and surface features
    - Convection currents

Assessment:

- Formative Assessments
    - Daily Class Warm-Ups
    - Concept Maps of the layers of the Earth
- Summative Assessments
    - Unit 2 Exam
- Formation of Earth Essay
    - Students will research the theories behind the formation of Earth and

- Major plates and boundaries
- Volcanoes and mountains
- Explain the Impact of these forces on history of earth and society
- Describe the Celestial Coordinate Systems including
  - Horizon and equatorial systems
  - Celestial models and locating objects in sky
  - Altitude, azimuth, ascension and declination
- Relate the celestial coordinate system to ancient and modern navigation
- Explain Earth's motion and seasonal cycles, what causes them and how they explain natural phenomena like:
  - Rotation and night and day
  - Axial tilt and seasons
  - Revolution and solstices and equinoxes
  - Day length and solar angles
  - Simulations, sun path, and angles

Core Student Activities: Students will complete/participate in the following:

- Inquiry lab using slinkies to analyze seismic data.
- Radiometric decay lab using pennies to describe production of heat in earth's core
- Build clay or cardboard models to simulate plate boundaries
- Design a buildings that can withstand virtual earthquakes
- Use celestial map and coordinates to locate celestial objects
- Prepare a physical model to demonstrate effect of axial tilt on angle of sunlight and amount of light on different areas of globe

Materials and Resources:

- Slinkies, foam, data charts, diagrams of P- and S-waves
- Pennies or candies, decay charts, graph paper or spreadsheet software
- Toothpicks, marshmallows, foam trays, shake table (or books and ruler)
- Clay and cardboard
- Local rock samples

present their findings as a formal paper

- Constellation Presentations
  - Students will conduct research into various constellations presenting their facts and findings to the class
- Coordinate System Modeling
  - Modeling of our two common coordinate systems for navigating the sky, horizontal and equatorial
- Stellarium Lab
  - Investigation into the night sky utilizing Stellarium
  - Students apply their understanding of the coordinate systems to this lab

- Lamp (sun), globe or ball (Earth), protractor, sunlight meter or angle measurement tool.

Instructional Methods:

- Direct Instruction and Guided Notes
  - Teacher-led instruction introduces Earth's structure, formation, coordinate systems, constellations, and methods for describing the night sky.
  - Students complete guided notes and daily warm-ups to reinforce key ideas.
- Research and Presentation
  - Students research the formation of Earth and selected constellations using teacher-approved sources.
  - Students present their findings to the class.
- Physical Modeling
  - Students use models to represent Earth's layer and the horizontal and equatorial coordinate systems.
  - Students apply the models to locate and describe objects in the night sky.
- Computer-Based Investigation
  - Students use Stellarium to investigate the night sky and locate celestial objects.
  - Students apply their knowledge of celestial coordinates to identify and describe objects in Stellarium.

Extensions:

- Local rock findings and relation to earth's formation and changes
- Using GPS to provide evidence for plate movement

Remediation:

- Teacher prepared videos
  - Equinox vs Solstice
  - Why are there seasons?
  - Horizontal & Equatorial Coordinates
  - Stellarium Walkthrough
  - The Theory of Plate Tectonics
  - The Layers of the Earth

Unit 3: Understanding the Sky	Time: 2-3 weeks

Academic Standards:

3.2.9-12 S Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

3.3.9-12 D Use mathematical or computational representations to predict the motion of orbiting objects

3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces

3.5.9-12.JJ Identify and explain how the evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools, materials, and processes.

Essential Content/Objective: At the end of the unit, students will be able to:

- Describe the Motion of Celestial Objects such as constellations and planets and and how they relate to both Earth's revolution and rotation
- Relate the observations of constellations on culture and society including:
  - Seasonal constellations and historical significance
  - Development of calendar and mythology
  - Cultural interpretations of well known constellations
  - Star mapping and technology - Hubble and JWST and others
- Describe the characteristics of the moon including:
  - Key lunar surface features
  - Its geology and history and relation to earth and other bodies
  - Current satellite observations of moon and implications for exploration
  - Why we see phases of the moon
- The nature of the phenomena of eclipses including:
  - Definition and types
  - Necessary alignments for eclipses to occur
  - Frequency of eclipses and why
- Explain the observation of regular tides and our theory behind their formation including:
  - Impact of gravitational forces and landforms
  - Their types of tides and frequency

Assessment:

- Formative Assessments
  - Daily Class Warm-Ups
  - Concept Maps of the Moon's features and eclipses
- Summative Assessments
  - Unit 3 Exam
- Moon Phase Journal
  - Students will track the phases of the Moon for the entirety of its orbital period, one month
- Eclipse Modeling
  - Modeling of the three different types of eclipses, lunar, solar, and annular
  - Understanding the differences between total and partial eclipses
- Space Race Investigation
  - Chronological understanding of the time frame for humans to reach the Moon

Core Student Activities: Students will complete/participate in the following:

- Use Virtual planetarium - stellarium to chart movement of stars and other celestial objects
- Model phases of the moon physically in a dark room with lamp, earth and moon
- Create and keep a Moon journal - record and draw and graph
- Physically model solar and lunar eclipses with styrofoam balls and bulb
- Research tide charts and correlate with land forms, latitude, and moon cycle
- Label moon map using proper terminology
- Culture and night sky presentations. Student chose different cultures and create slide show as to how these cultures analyzed the night sky
- Use string and masses or graphing software to model how gravitational force changes with distance

Materials and Resources:

- Styrofoam balls and lamps
- Toothpicks, rods, and string
- Oreos
- Construction paper
- Chromebooks
- Rulers, protractors, and angle measurements

Instructional Methods:

- Direct Instruction and Guided Notes
    - Teacher-led instruction introduces lunar features, phases, eclipses, and the history of lunar exploration.
    - Students complete guided notes, warm-ups, and concept maps to reinforce key concepts.
- Observation and Journaling
    - Students observe and document the Moon's changing appearance throughout its orbital cycle.
    - Students use their observations to identify patterns in the Moon's phases.

Extensions:

- Students create a star clock using big dipper and polaris
- Model lunar phases with Oreo cookies
- Use Moontrek or skyview to analyze moons surface and find locations

Remediation:

- Teacher prepared videos
    - Moon Phases Explained
    - Why Does the Moon Have Phases?
    - Lunar vs. Solar Eclipses
    - How Do Eclipses Occur?
    - Total, Partial, and Annular Eclipses
    - Major Events of the Space Race
    - Apollo Missions and the Moon Landing
    - History of Human Spaceflight

• Physical Modeling
  ○ Students use models to demonstrate the positions of the Earth, Moon, and Sun during different phases and types of eclipses.
  ○ Students use the models to distinguish between total, partial, solar, lunar, and annular eclipses.
• Historical Investigation
  ○ Students investigate major events and missions of the Space Race.
  ○ Students organize important events chronologically to understand the progression toward human exploration of the Moon.	

Unit 4: Light and Telescopes	Time: 2-3 weeks

Academic Standards:

3.2.9-12.B Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

3.5.9-12.NN Analyze the rate of technological and engineering development and predict future diffusion and adoption of new innovations and technologies.

3.2.9-12.X Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.

3.2.9-12.V 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.

3.3.9-12.B Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, the motion of distant galaxies, and the composition of matter

Essential Content/Objective: At the end of the unit, students will be able to:

- Describe the nature of light including:
  - Its core nature as both mass and energy
  - Properties of light such as wavelength, energy, and frequency and their application to astronomy
  - A photon as a discrete amount of energy (Quantitized light)
  - The speed of light and its application to astronomy
  - The production of light and emission spectra
- Explain how light Interacts with matter including the photoelectric effect and absorption spectra
- Describe Telescopes including their:
  - Design
  - Types and the role of refracting and reflecting lenses
  - Design in terms of which lens and size of lens to capture light
  - Different types of telescopes (light, radio, etc)
  - Location and advantages of both space and earth telescopes

Assessment:

- Formative Assessments
  - Daily Class Warm-Ups
  - Concept Maps of the different types of telescopes and forms of electromagnetic radiation
- Summative Assessments
  - Unit 4 Exam
- Electromagnetic Spectrum Analysis
  - Learning the relationships between a light source's frequency and wavelength
  - Classifying the different regions of the electromagnetic spectrum based on wavelength, frequency, and energy
- Flame Test Lab
  - Observing the characteristic colors produced by different elements
  - Connecting flame colors to atomic

Core Student Activities: Students will complete/participate in the following:

- Create a scaled visual model of the EM spectrum (radio to gamma) and label real-world sources and detection tools (e.g., Hubble vs. JWST vs. Chandra).
- Use PhET or Pivot Interactives to simulate how light ejects electrons from a metal surface.
- Use converging lenses to build a Galilean or Keplerian telescope.
- Draw ray diagrams for convex lenses and concave mirrors. Use pHet optics bench
- Compare visible, infrared, and radio telescope performance from Earth vs. space.
- Observe emission spectra from gas tubes and absorption spectra from light through filters.

emission spectra and the energy of electrons

- Atmosphere in a Fish Tank Demonstration
    - Modeling the scattering of light as it passes through Earth's atmosphere
    - Observing how different wavelengths of light are scattered and connecting the demonstration to the blue sky and red sunsets
- Photoelectric Effect
    - Calculating the energy and velocity of electrons emitted when light strikes a material
    - Investigating the relationship between light frequency, photon energy, and electron kinetic energy

Materials and Resources:

- Satellite dish
- Lenses and mirrors
- Rolled craft paper
- Gas discharge tubes and diffraction gratings

Instructional Methods:

- Direct Instruction and Guided Notes
    - Teacher-led instruction introduces telescopes, electromagnetic radiation, light, and spectroscopy.
    - Complete guided notes, warm-ups, and concept maps to reinforce key concepts.
- Laboratory and Demonstrations
    - Students conduct investigations involving light, atomic emission spectra, and the scattering of light.

Extensions:

- Students build a basic radio telescope using a satellite dish, software-defined radio (SDR) dongle, and free spectrum-analysis software. Try to listen to the Sun or Jupiter
- Students create visual artwork representing different forms of EM radiation.

Remediation:

- Teacher prepared videos
    - Types of Telescopes
    - How Telescopes Work
    - The Electromagnetic Spectrum
    - Wavelength, Frequency, and Energy
    - Atomic Emission Spectra
    - Light Scattering and Earth's

○ Use observations and data to connect demonstrations to astronomical phenomena. ● Mathematical Analysis ○ Calculate relationships between wavelength, frequency, energy, and the speed of light. ○ Apply mathematical relationships to analyze electromagnetic radiation and the photoelectric effect. ● Modeling and Data Analysis ○ Use models and diagrams to represent different types of telescopes and regions of the electromagnetic spectrum. ○ Analyze light and spectra to understand how astronomers gather information about distant objects. NASA similarly emphasizes using different wavelengths and spectra to study the properties and composition of astronomical objects.	Atmosphere ○ The Photoelectric Effect ○ How Astronomers Use Light to Study the Universe

Unit 5: The Solar System	Time: 2-3 weeks

Academic Standards:

3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles

3.2.9-12.LUse mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects

3.2.9-12.I 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.

3.3.9-12.D Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Essential Content/Objective: At the end of the unit, students will be able to:

- Explain the formation of other planets starting with the formation of the sun
- Describe the difference and reasons behind formation of rocky planets and gaseous planets
- Identify the relative compositions of planets and explanations
- Describe the role of gravity on all solar system objects - asteroids, comets, planets
- Explain the nature of Nebulae and their role as stellar nurseries
- Describe moon formation around other planets - their characteristics and interest and how it compares to the formation of Earth's moon
- Create a timeline of solar system exploration - history and objectives and key moments
- Explain the origins and importance of the "Space race"

Core Student Activities: Students will complete/participate in the following:

- Students use digital platforms (like PhET or Universe Sandbox) or physical models (e.g., flour and marbles) to simulate the collapse of a solar nebula and the formation of a protostar and protoplanetary disk.
- In teams, students investigate and present profiles of two planets—one inner and one outer—comparing composition, atmospheres, temperature, moons, and surface features.

Assessment:

- Formative Assessments
  - Daily Class Warm-Ups
  - Concept Maps comparing the inner and Jovian planets
- Summative Assessments
  - Unit 5 Exam
- Inner and Jovian Planet Research
  - Research and compare the physical characteristics and compositions of the inner and Jovian planets.
  - Students will examine differences in size, atmosphere, temperature, and overall structure
- Solar System Model
  - Constructing models representing the planets and their arrangement within the solar system
- Planetary Water and Life Investigation
  - Investigate the presence of water and the potential for life on different planets and planetary bodies

- Students research extremophiles on Earth and use that data to develop a hypothesis about which moons/planets could support similar life
- Students choose a celestial body (e.g., Mars, Europa, Titan) and analyze key discoveries that relate to early Earth's history
- Use scale models and data to investigate why the Sun contains 99% of the mass and how gravity influences planetary orbits and atmospheric retention
- Students act as NASA scientists and design a mission to investigate habitability on a selected planet or moon, including instruments, landing sites, and goals.
    - Use scientific evidence to compare the conditions necessary for life on Earth with those found elsewhere in the solar system
- Planetary Deep Dive Essay
    - Conduct an in-depth investigation of a selected planet
    - Use research to explain the planet's composition, characteristics, exploration history, and potential for water or life.

Materials and Resources:

- Flour, cocoa powder, or cornmeal (for nebula modeling)
- Marbles or steel balls (simulate planetesimals/protoplanets)
- Round trays or pans
- Straws (to blow and simulate gas dispersion)
- Computers
- LEGO robotics kit, TinkerCAD, or digital design tools for modeling rovers/instruments

Instructional Methods:

- Direct Instruction and Guided Notes
    - Teacher-led instruction introduces the characteristics, composition, and formation of the planets.
    - Students use guided notes, warm-ups, diagrams, and class discussion to reinforce key concepts.
- Research and Investigation
    - Students research the inner and Jovian planets, including their composition, water, potential for life, and exploration missions.
    - Students use scientific sources to compare the characteristics of different planets.
- Physical Modeling

Extensions:

- Students use authentic data from missions like Juno, Cassini, or Perseverance to explore planetary characteristics, moon geology, or atmosphere composition.
- Students evaluate current exoplanet discoveries (Kepler, TESS) and argue whether life could exist elsewhere. Write a formal CER essay or hold a classroom debate.

Remediation:

- Teacher prepared videos
    - Overview of the Solar System
    - Inner vs. Outer Planets
    - The Terrestrial Planets
    - The Jovian Planets
    - Planetary Composition
    - Water in the Solar System
    - The Search for Life Beyond Earth
    - Major Missions to the Planets
    - Comparing the Planets

○ Construct and use a model representing the relative order, size, and arrangement of objects in the solar system. ○ Students use the model to identify patterns and differences between the inner and outer planets. ● Written Analysis ○ Students complete a planetary deep-dive essay examining the physical characteristics and scientific importance of a selected planet. ○ Students support their writing with evidence gathered from research.	○ How We Explore the Solar System

Unit 6: Stars	Time: 2-3 weeks

Academic Standards:

3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles

3.2.9-12.L Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects

3.3.9-12.D Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

3.3.9-12.A 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

3.3.9-12.C Communicate scientific ideas about the way stars, over their life cycle, produce elements.

3.2.9-12.G Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.

3.2.9-12.H Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Essential Content/Objective: At the end of the unit, students will be able to:

- Describe historical and present stellar formation from nebulae and the origins of nebulae themselves
- Relate the role of gravity and fusion in star formation and behavior including the synthesis of elements, the conversion of mass defect into energy via $E=mc^2$ and how the changes in gravity and fusion cause changes in stars behavior
- Describe hydrostatic equilibrium and main sequence stars including:
  - What is hydrostatic equilibrium?
  - What are the main sequence stars?
- Role of mass in a stars life cycle including the significance of color and brightness of star - apparent magnitude
- Describe the factors that cause Nova and Supernova
- Identify and compare the types of stars and examples in the night sky
- Explain the nature of a black hole

Assessment:

- Formative Assessments
  - Daily Class Warm-Ups
  - Concept Maps of the stages of stellar evolution
- Summative Assessments
  - Unit 6 Exam
- Stellar Life Cycle Modeling
  - Constructing models showing the major stages in the life cycle of a star
  - Comparing the life cycles of Sun-like and massive stars
- Stellar Mass and Life Span Investigation
  - Investigating how a star's mass affects its temperature, fuel consumption, and overall life span

Core Student Activities: Students will complete/participate in the following:

- Use diagrams, flowcharts, or digital simulations to model the stages of stellar evolution from nebula to white dwarf, neutron star, or black hole
- Examine real or simulated spectral data to determine the composition and temperature of stars
- Use balloon-and-string models, interactive simulations (e.g., PhET), or math-based visualizations to explore how gravity and fusion pressure balance in a main-sequence star.
- Use proportional modeling or physical walks (scaled solar system/universe on a football field) to experience the size and distance relationships of astronomical objects
- Using online simulations, students explore supernova explosions and track how elements like gold and uranium are synthesized and dispersed.
- Identify constellations, planets, and types of stars (red giants, main-sequence stars) using star charts or apps like Stellarium
    - Comparing the expected life spans and final stages of stars of different masses
- Nuclear Fusion and Elemental Pathways
    - Tracing the progression of elements produced through nuclear fusion during different stages of stellar evolution
    - Connecting nuclear fusion to the energy produced within stars.
- Hydrostatic Equilibrium Investigation
    - Investigating the balance between the inward force of gravity and the outward pressure produced by energy from the star's core
    - Explaining how this balance changes as a star uses up its nuclear fuel
- Journey Through the Life of a Star
    - Students will create their own star and determine its life cycle based on its initial mass
    - Students will describe the major stages their star experiences and determine its eventual fate

Materials and Resources:

- Chromebooks and Astrosim
- Chart paper and markers
- Star spectra printouts
- Balloons, string, rubber bands
- Measuring tape, sidewalk chalk
- Inside a supernova - Harvard

Instructional Methods:

- Direct Instruction and Guided Notes

Extensions:

- Students work in teams to design a proposal for a new space-based observatory that will detect specific phenomena (e.g., exoplanets, black holes, early galaxies). They must justify instrument choices (radio, IR, X-ray, etc.) and orbital placement (e.g., Lagrange point, Earth orbit).
- Planet Hunters TESS (via Zooniverse) to help NASA identify exoplanets. Students analyze

○ Teacher-led instruction introduces stellar formation, evolution, nuclear fusion, and stellar death. ○ Students complete guided notes, warm-ups, diagrams, and class discussions to reinforce concepts. ● Modeling and Visualization ○ Students use physical and visual models to represent the stages of stellar evolution. ○ Students compare the different paths stars take based on their initial mass. ● Scientific Investigation ○ Students investigate the relationships between stellar mass, energy production, life span, and stellar evolution. ○ Students use evidence and models to explain changes that occur throughout a star's life. ● Student-Created Modeling ○ Students create their own star and determine its life cycle based on its characteristics. ○ Students explain the reasoning behind the evolutionary path and final stage of their star.	light curves from TESS data to flag potential transits. **Remediation:** ● Teacher Prepared Videos ○ How Stars Are Born ○ The Life Cycle of a Star ○ Main Sequence Stars ○ Stellar Mass and Life Span ○ Hydrostatic Equilibrium ○ Nuclear Fusion in Stars ○ How Stars Make Elements ○ Sun-Like Stars vs. Massive Stars ○ Supernovae and Stellar Death ○ White Dwarfs, Neutron Stars, and Black Holes

Unit 7: Cosmology	Time: 2-3 weeks

Academic Standards:

3.2.9-12.P Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles

3.2.9-12.LUse mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects

3.2.9-12.I 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.

3.3.9-12.A 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

3.2.9-12.H Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

3.2.9-12.O Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

3.3.9-12.B Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, the motion of distant galaxies, and the composition of matter in the universe

Essential Content/Objective: At the end of the unit, students will be able to:

- Describe the various aspects of the Big Bang Theory including:
  - Timeline
  - The catalyst for its beginning
  - Evidence for it - CMB, redshift and doppler effect, abundance of hydrogen, expanding Universe, redshift and doppler effect, and rate of expansion
- Explain how we estimate the age and structure of universe including:
  - How is age estimated?
  - The different types of galaxies and formation?
  - Observable limits into space and time
  - Where are we?
- Explain the various theories as to the fate of the universe and predictions of outcomes

Assessment:

- Formative Assessments
  - Daily Class Warm-Ups
  - Concept Maps including galaxies, expansion, the Big Bang, dark matter, and dark energy
- Summative Assessments
  - Unit 7 Exam
- Big Bang Evidence Investigation
  - Students will examine evidence supporting the Big Bang theory, including cosmic expansion, redshift, the cosmic microwave background, and the abundance of light elements.
- Hubble's Law Investigation

Core Student Activities: Students will complete/participate in the following:

- Students observe and record light spectra using a redshift simulator (online or physical), then graph galaxy speed vs. distance to discover Hubble's Law
- Students examine a real image of the cosmic microwave background (CMB), then build a scaled model or color map representing temperature fluctuations.
- Students construct a visual timeline from the Big Bang to the present, placing key events: inflation, CMB, element formation, galaxy formation, solar system formation
- Students are assigned elements and must research where and how they formed (Big Bang, fusion in stars, or supernova). Present findings in a creative way (card, TikTok-style video, or comic strip).
- Students analyze a high-resolution image like the **Hubble Ultra Deep Field**, estimate ages of visible galaxies, and reflect on what the image reveals about cosmic history
- Students research different models of the universe's fate (Big Crunch, Heat Death, Big Rip) and debate which scenario is most plausible based on current evidence.
    - Students will analyze data comparing the distance and recession velocity of galaxies.
    - Students will use the data to identify the relationship between galaxy distance and the expansion of the universe.
- Timeline of the Universe
    - Students will create a timeline showing major events in the history of the universe.
- Galaxy Classification and Investigation
    - Students will examine images of galaxies and describe differences in their structures and characteristics.
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- Fate of the Universe Assignment
    - Students will investigate possible outcomes for the future of the universe.

Materials and Resources:

- Research articles, graphic organizer
- Chromebooks
- Hubble images via hubblesite
- Cosmic origin code periodic table
- Markers sticky notes and chart paper
- Digital heat map tool
- Light spectra printouts

Extensions:

- Students become real contributors to astrophysics by joining Galaxy Zoo on Zooniverse.org, where they classify galaxies based on shape, structure, and orientation. Students analyze trends in galaxy types to make inferences about galactic evolution.
- Students design a conceptual model (physical or digital) representing cosmic inflation. They must explain how it accounts for the

Instructional Methods:

- Direct Instruction and Guided Notes
  - Teacher-led instruction introduces the Big Bang theory, expansion of the universe, galaxies, and evidence supporting modern cosmology.
  - Students complete guided notes, diagrams, warm-ups, and class discussions.
- Data Analysis
  - Analyze astronomical data involving galaxy distance, redshift, and expansion.
  - Students use evidence and mathematical relationships to identify patterns in the expanding universe.
- Modeling and Visualization
  - Construct timelines and visual models to represent the history and expansion of the universe.
  - Use models to connect observations to current theories of cosmic evolution.
- Research and Scientific Communication
  - Research topics related to galaxies, the Big Bang, or the future of the universe.
  - Communicate their findings through written assignments and class discussion.

smoothness of the CMB and the structure of today's universe.

Remediation:

- Teacher Prepared Videos
  - What Is Cosmology?
  - The Big Bang Theory
  - Evidence for the Big Bang
  - The Expanding Universe and Redshift
  - Hubble's Law
  - Cosmic Microwave Background
  - Types of Galaxies
  - The Future of the Universe