NEW MILFORD PUBLIC SCHOOLS

New Milford, Connecticut

Astronomy College Prep

June/2022

BOE Approved August 2022

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New Milford's Mission Statement

The mission of the New Milford Public Schools, a collaborative partnership of students, educators, family and community, is to prepare each and every student to compete and excel in an ever-changing world, embrace challenges with vigor, respect and appreciate the worth of every human being, and contribute to society by providing effective instruction and dynamic curriculum, offering a wide range of valuable experiences, and inspiring students to pursue their dreams and aspirations.

Astronomy College Prep

Grades 11 & 12

In this semester course, students will explore the universe and discover unseen worlds. Major topics of this course include lunar phases, the celestial sphere, electromagnetic radiation, the solar system, stars, black holes, galaxies and the search for extraterrestrial life. There is also involvement with the John J. McCarthy Observatory outside the scope of the school day. Prerequisites include the successful completion of Biology or Integrated Science.

Pacing Guide

Unit	Number of Weeks
1: Astronomy Basics	4
2: The Birth of Modern Astronomy	3
3: Tools of the Astronomer	3
4: The Solar System	4
5: Stars	3
6: Galaxies and Cosmology	3

Key for National and State Standards

HS-PS = Next Generation Science Standards: Physical Sciences

HS-ES = Next Generation Science Standards: Earth Sciences

RST = Common Core Reading Standards for Literacy in Science 6-12

WHST = Common Core Writing Standards for Science and Technology

5E Model (used in lieu of WHERETO)
E1 - Engage (H)
E2 - Explore (E_1,T)
E3 - Explain (W,T,O)
E4 - Extend (R,T)
E5 - Evaluate (E_2)

Unit 1: Our Place in Space

Phenomenon: Various Images/Videos of Sun, Moon and Stars that demonstrate cyclic patterns

Stage 1 Desired Results

ESTABLISHED GOALS

MS-ESS1-1: Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons

CCSS.ELA-LITERACY.RST 11-12.2: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler, but still accurate terms

CCSS.ELA-LITERACY.RST 11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in text

CCSS.ELA-LITERACY.RST 11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and

Transfer

Students will be able to independently use their learning to…

- SEP 1 - Ask questions
- SEP 2 - Develop and use models

Meaning

UNDERSTANDINGS

Students will understand that…

ESS1.A: The Universe and Its Stars

- Patterns of the apparent motion of the sun, the moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

ESS1.B: Earth and the Solar System

- This model of the solar system can explain eclipses of the sun and the moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of

ESSENTIAL QUESTIONS

Students will keep considering…

How are physical laws used to explain and predict the motions of objects in space?

How does electromagnetic radiation make it possible to study objects which are too distant to visit?

topics.	Earth across the year. (MS-ESS1-1)	
	Acquisition	
	Students will know… ● Astronomy is the study of the universe; all of space, time, matter and energy ● The Celestial Sphere is an imaginary sphere surrounding the Earth onto which all astronomical objects are projected ● Celestial coordinates are akin to latitude and longitude on Earth and are used to locate objects reliably in the night sky ● Objects appear to change position in the sky due to the relative position of the Earth in its orbit around the Sun and astronomical objects have been used for timekeeping for millennia due to the regularity of their motions ● Lunar phases and eclipses are the result of the current relative positions of the Sun, Moon and Earth ● Eclipses can be Lunar or Solar and do not occur every month due to the tilted orbit of the Moon ● Parallax is the apparent shift in position of a nearby object in relation to a more distant background and can be used to determine distances to faraway objects ● **CCC: Patterns -** Empirical evidence is needed to identify patterns.	*Students will be skilled at…* ● Analyzing and evaluating journal articles which address various astronomical topics and writing concise yet accurate article summaries ● Explaining the concept of the celestial sphere and the use of angular measurement to locate objects in the sky ● Describing how and why the Sun, Moon and stars appear to change position from night to night and month to month ● Explaining how clocks and calendars are linked to Earth's rotation and orbit around the Sun ● Showing how the relative motions of Earth, the Sun and the Moon lead to lunar phases and eclipses ● Explaining the simple geometric reasoning that allows astronomers to measure the distances and sizes of otherwise inaccessible objects ● Applying what they know about celestial coordinates to use a planisphere to locate objects in the sky ● Applying their knowledge of the relative positions of sun, moon and Earth to accurately construct a lunar phase diagram

Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
T, M, A	Rubric focusing on content, accuracy, synthesis of concepts and reflection	PERFORMANCE TASK(S): *Students will show that they really understand evidence of…* *The application of celestial coordinates to objects/constellations in the sky and the relationship between the Earth's actual position/orientation in space and the apparent locations of objects/constellations visible in the night sky.* **Goal:** To accurately use celestial coordinates to map out several objects/constellations in the night sky **Role:** Ancient Greek Natural Philosopher **Audience:** The Platonic Academy **Situation:** You have been asked to present your findings to the other natural philosophers at the Platonic Academy regarding the application of the celestial coordinate system **Product or Performance:** Report with accurate celestial coordinates of several objects/constellations in the night sky and explanations to questions about Earth's actual position in space and the apparent locations of these objects in the night sky over the course of the year. **Standards for Success:** Rubric

		OTHER EVIDENCE: *Students will show they have achieved Stage 1 goals by…* ● Quizzes and Tests ● Formative assessments ● Lab analysis and reflection on results ● Warm-ups and exit tickets ● Article readings/summaries ● Homework assignments

Stage 3 – Learning Plan		
Code	***Pre-Assessment*** ● Brainstorming at the start of the unit ● Informal assessment of prior knowledge ● Developing questions related to upcoming unit	
	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring
M, A	**Teacher prepares notes and leads class discussions** - to introduce unit, provide content, provide opportunity formative assessment, and address misconceptions (E3)	● Quizzes on content ● Questions on activities and projects ● Verbal questions for comprehension ● End of Unit assessment
T, A	**Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries (E2, E4, E5) Ex: Science Daily	
T, M, A	**Lunar Phases Lab** - students use their knowledge of the relative positions of sun, moon and Earth to accurately construct a lunar phase diagram (E1, E3)	
M, A	**Parallax Lab** - students use the principle of parallax to indirectly measure the length of their outstretched arm (E1, E2, E3)	

Unit 2: The Birth of Modern Astronomy

Phenomenon: Orbiting Planet Model/Video

Stage 1 Desired Results

ESTABLISHED GOALS

HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

CCSS.ELA-LITERACY.RST 11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account

CCSS.ELA-LITERACY.RST 11-12.2: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler, but still accurate terms

CCSS.ELA-LITERACY.RST 11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

Transfer

Students will be able to independently use their learning to…

- SEP 4 - Analyze and interpret data
- SEP 5- Use mathematical and computational thinking
- SEP 8 - Obtain, evaluate and communicate information

Meaning

UNDERSTANDINGS

Students will understand that…

ESS1.B: Earth and the Solar System

- Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4)

ESSENTIAL QUESTIONS

Students will keep considering…

How are physical laws used to explain and predict the motions of objects in space?

How has technology been used to increase our knowledge and understanding of the universe?

What are some of the most important discoveries in astronomy and who are the scientists credited with these discoveries?

CCSS.ELA-LITERACY.RST 11-12.8: Evaluate the hypotheses, data, analyses, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information CCSS.ELA-LITERACY.RST 11-12.9: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible		
	Acquisition	
	Students will know… ● Astronomy's ancient roots can be found in structures built all over the globe ● The major contributions to astronomy of Eratosthenes, Copernicus, Galileo and Kepler ● Kepler's Laws of Planetary Motion accurately predict the orbital periods and distances of the planets from the Sun ● Newton's Laws of Motion and Universal Gravitation are essential to our understanding of the universe ● **CCC: Interdependence of Science, Engineering, and Technology -** Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. ● **CCC: Scale, Proportion, and Quantity -** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth)	*Students will be skilled at…* ● Analyzing and evaluating journal articles which address various astronomical topics and writing concise yet accurate article summaries ● Summarizing the role of Renaissance science in the history of astronomy ● Creating a biographical presentation outlining the accomplishments of a notable astronomer ● Stating Kepler's laws of planetary motion and explaining how Kepler's laws allow us to construct a scale model of the solar system ● Stating Newton's laws of motion and universal gravitation and explaining how they account for Kepler's laws ● Explaining how the law of gravitation enables us to measure the masses of astronomical bodies ● Re-creating the experiment conducted by Eratosthenes which accurately measured the circumference of the Earth around 200 BC ● Validating Kepler's Third Law of Planetary Motion by applying modern values for the orbital periods and distances of the planets in the solar system

Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
T, A	NMHS Communication Rubric includes:purpose, organization, conventions, development Communication Rubric	PERFORMANCE TASK(S): *Students will show that they really understand evidence of…* *The significant contributions of astronomers over the last 500 years and their importance in our current understanding of the cosmos* **Goal:** To create a short presentation showcasing the life and discoveries of a prominent astronomer **Role:** A councilor at astronomy camp **Audience:** 6th grade campers **Situation:** Your responsibility is to get the campers excited about astronomy **Product or Performance:** Short presentation on a prominent astronomer to show to a group of 6th grade campers before they use binoculars and telescopes on a clear, dark night. **Standards for Success:** Rubric
		OTHER EVIDENCE: *Students will show they have achieved Stage 1 goals by…* ● Quizzes and Tests ● Formative assessments ● Lab analysis and reflection on results ● Warm-ups and exit tickets ● Article readings/summaries ● Homework assignments

Stage 3 – Learning Plan		
Code	***Pre-Assessment*** ● Brainstorming at the start of the unit ● Informal assessment of prior knowledge ● Developing questions related to upcoming unit	
	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring
M, A	**Teacher prepares notes and leads class discussions** - to introduce unit, provide content, provide opportunity formative assessment, and address misconceptions (E3)	● Quizzes on content ● Questions on activities and projects ● Verbal questions for comprehension ● End of Unit assessment
T, A	**Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries (E2, E4, E5) Ex: Science Daily	
T, A	**Eratosthenes Measures Earth Lab** - students re-create the experiment conducted by Eratosthenes which accurately measured the circumference of the Earth around 200 BC (E1, E2, E3)	
T, M, A	**Kepler's Third Law Lab** - students use modern values for the orbital periods and distances of the planets in the solar system to validate Kepler's Third Law of Planetary Motion. Then Kepler's 3rd law is used to predict the mass of Cygnus X-1, the first black hole discovered in the Milky Way. (E2, E3)	

Unit 3: Tools of the Astronomer

Phenomenon: Spectroscopic Image of Sunlight

Stage 1 Desired Results

ESTABLISHED GOALS

HS-PS4-5: 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.

CCSS.ELA-LITERACY.RST 11-12.2: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler, but still accurate terms

CCSS.ELA-LITERACY.RST 11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in text

CCSS.ELA-LITERACY.RST 11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context

Transfer

Students will be able to independently use their learning to…

- SEP 4 - Analyze and interpret data
- SEP 6 - Construct explanations

Meaning

UNDERSTANDINGS

Students will understand that…

PS4.A: Wave Properties

- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-5)

PS4.B: Electromagnetic Radiation

- Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in

ESSENTIAL QUESTIONS

Students will keep considering…

How does electromagnetic radiation make it possible to study objects which are too distant to visit?

How has technology been used to increase our knowledge and understanding of the universe?

relevant to grades 11-12 texts and topics	microscopic quantities. *(secondary to HS-ESS1-2)*	
	Acquisition	
	Students will know… ● Electromagnetic radiation is a form of energy transfer which propagates through space and is categorized based on wavelength(Gamma Rays, visible light, infrared, etc.) ● Thermal radiation is generated by all objects in the universe and can be used to determine an object's surface temperature using radiation laws (Wien's Law, Stefan's Law) and a blackbody curve ● The Doppler Effect is the change in frequency of a wave for an observer moving relative to its source; this change in frequency can be measured and used to determine line of sight velocity of a radiating object ● Spectroscopy is used to study the nature of radiating objects and many physical properties of radiating objects can be determined by analyzing their spectra(composition, temperature, line of sight velocity, etc.) ● Kirchhoff's Laws distinguish the different varieties and origins of spectra ● Telescopes are designed to gather and focus light from dim or distant objects and come in many varieties based on the type of electromagnetic radiation they are designed to collect ● Advantages and disadvantages of the various types of telescopes (optical, radio, etc.) ● The atmosphere absorbs most types of electromagnetic radiation so some telescopes must be located in orbit	*Students will be skilled at…* ● Analyzing and evaluating journal articles which address various astronomical topics and writing concise yet accurate article summaries ● Discussing the nature of electromagnetic radiation and how radiation transfers energy and information through interstellar space ● Describing the characteristics of spectra and the conditions under which they are produced and explaining the kinds of information that can be obtained by analyzing the spectra of astronomical objects ● Observing and drawing the emission spectra of several gases and using the results to predict the composition of overhead fluorescent lamps ● Sketching and describing the basic designs of the major types of optical telescopes ● Describing how Earth's atmosphere affects astronomical observations and discussing some of the current efforts to improve ground-based astronomy ● Discussing the advantages and disadvantages of radio astronomy compared with optical observations ● Explaining why some observations are best done from space, and discussing the advantages and limitations of space-based astronomy

	● Analyzing the full spectrum of electromagnetic radiation from an object provides valuable insight about processes which are invisible ● **CCC: Cause and Effect -** Systems can be designed to cause a desired effect. ● **CCC: Interdependence of Science, Engineering, and Technology -** Science and engineering complement each other in the cycle known as research and development (R&D) ● **CCC: Influence of Engineering, Technology, and Science on Society and the Natural World -** Modern civilization depends on major technological systems	

Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
T, M, A	Rubric to assess for claim accuracy, appropriate evidence and reasoning that connects to content accurately	PERFORMANCE TASK(S): *Students will show that they really understand evidence of…* *How the spectral patterns of different elements are unique and the composition of an unknown mixture of gases can be determined by analyzing its light using spectroscopy.* **Goal:** To identify the composition of a mixture of unknown gases **Role:** Lab Tech at a lighting company **Audience:** Head Chemists **Situation:** You have been asked by your boss to evaluate a tube of unknown gases and to identify the composition of the gases in the tube **Product or Performance:** Detailed report with standard spectral samples of known gases, the unknown spectral pattern and an analysis of the composition with evidence and reasoning to support your claims **Standards for Success:** Rubric
		OTHER EVIDENCE: *Students will show they have achieved Stage 1 goals by…* ● Quizzes and Tests ● Formative assessments ● Lab analysis and reflection on results ● Warm-ups and exit tickets ● Article readings/summaries ● Homework assignments

Stage 3 – Learning Plan		
Code	***Pre-Assessment*** ● Brainstorming at the start of the unit ● Informal assessment of prior knowledge ● Developing questions related to upcoming unit	
	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring
M, A	**Teacher prepares notes and leads class discussions** - to introduce unit, provide content, provide opportunity formative assessment, and address misconceptions (E3)	● Quizzes on content ● Questions on activities and projects ● Verbal questions for comprehension ● End of Unit assessment
T, A	**Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries (E2, E4, E5) Ex: Science Daily	
M, A	**In-class Trip to Observatory** - students will be introduced to the observatory's facilities and be given an opportunity to evaluate the different types of telescopes and equipment used and to view the Sun in the telescope (E1)	

Unit 4: The Solar System

Phenomenon: Video of Collisions in Space (formation of solar system/meteorites)

Stage 1 Desired Results

ESTABLISHED GOALS

HS-ESS1-6: Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

CCSS.ELA-LITERACY.RST 11-12.2: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler, but still accurate terms

CCSS.ELA-LITERACY.RST 11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

CCSS.ELA-LITERACY.RST 11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to

Transfer

Students will be able to independently use their learning to…

- SEP 1 - Ask questions
- SEP 4 - Analyze and interpret data
- SEP 6 - Construct explanations
- SEP 8 - Obtain, evaluate and communicate information

Meaning

UNDERSTANDINGS

Students will understand that…

ESS1.C: The History of Planet Earth

- Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6)

ESSENTIAL QUESTIONS

Students will keep considering…

How has technology been used to increase our knowledge and understanding of the universe?

What methods make it possible to determine the evolutionary stages and ages of the Earth, stars and universe?

How is Earth similar to and different from the other planets in the solar system?

address a question or solve a problem CCSS.ELA-LITERACY.RST 11-12.9: Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible	**PS1.C: Nuclear Processes** ● Spontaneous radioactive decay follows a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary to HS-ESS1-6)*	
	Acquisition	
	Students will know… ● Planets are classified based on their physical characteristics ● Physical and orbital properties of the major non-planetary components of the solar system ● The solar system formed 4.6 billion years ago according to the latest evidence and collisions played a major role in determining its final configuration ● Radioactive decay of certain elements allows scientists to accurately date objects in the solar system ● **CCC: Stability and Change -** Much of science deals with constructing explanations of how things change and how they remain stable.	*Students will be skilled at…* ● Analyzing and evaluating journal articles which address various astronomical topics and writing concise yet accurate article summaries ● Summarizing the basic differences between the terrestrial and Jovian planets ● Identifying and describing the major non-planetary components of the solar system ● Summarizing the origin of the solar system ● Assembling a scale model of the solar system ● Using computer simulation software to model radioactive decay and using the findings to discuss how the age of the Earth was determined

Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
T, M	Project rubric which communicates expectations for both content and presentation criteria.	PERFORMANCE TASK(S): *Students will show that they really understand evidence of…* *The physical and orbital properties of objects in the solar system are varied and proper synthesis of these properties will determine what types of experiences astronauts/tourists will have when visiting these locations in the future.* **Goal:** To design an exciting resort at a unique destination in the solar system **Role:** Using your knowledge of the destination to create a fun, exciting resort and to present you ideas to your boss in a convincing manner **Audience:** Your boss and the Board of Directors **Situation:** The Board wants to go ahead with plans to build a resort and you must convince them that your resort is the one they should choose. **Product or Performance:** A sales pitch presentation showcasing your resort design **Standards for Success:** Rubric
		OTHER EVIDENCE: *Students will show they have achieved Stage 1 goals by…* ● Quizzes and Tests ● Formative assessments ● Lab analysis and reflection on results ● Warm-ups and exit tickets ● Article readings/summaries ● Homework assignments

Stage 3 – Learning Plan

Code		
	Pre-Assessment ● Brainstorming at the start of the unit ● Informal assessment of prior knowledge ● Developing questions related to upcoming unit	
	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring
M, A	**Teacher prepares notes and leads class discussions** - to introduce unit, provide content, provide opportunity formative assessment, and address misconceptions (E3)	● Quizzes on content ● Questions on activities and projects ● Verbal questions for comprehension ● End of Unit assessment
T, A	**Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries (E2, E4, E5) Ex: Science Daily	
T, A	**Solar System Modeling Activity** - students will assemble a scale model of the solar system (outside on field 1st semester, hallway 2nd semester) (E1, E2, E3)	
T, A	**In-Class Tour of Scale Model Solar System** - students will take a tour of the portion of the scale model solar system located on NMHS grounds (E1)	
T, M, A	**Radioactive Decay Simulation** - students will use computer simulation software to model radioactive decay and use the findings to discuss how the age of the Earth was determined (E2, E3)	

Unit 5: Stars

Phenomenon: HR Diagram; Images of Various Stages of Lives of Stars

Stage 1 Desired Results

ESTABLISHED GOALS

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

CCSS.ELA-LITERACY.RST 11-12.2: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler, but still accurate terms

CCSS.ELA-LITERACY.RST 11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in text

CCSS.ELA-LITERACY.RST 11-12.4:

Transfer

Students will be able to independently use their learning to…

- SEP 2 - Develop and use models
- SEP 4 - Analyze and interpret data
- SEP 6 - Construct explanations

Meaning

UNDERSTANDINGS

Students will understand that…

ESS1.A: The Universe and Its Stars

- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1)
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.(HS-ESS1-3)
- Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all

ESSENTIAL QUESTIONS

Students will keep considering…

How does electromagnetic radiation make it possible to study objects which are too distant to visit?

What methods make it possible to determine the evolutionary stages and ages of the Earth, stars and universe?

What is meant when it is said that we are all made of "star stuff"?

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics	atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-3) **PS3.D: Energy in Chemical Processes and Everyday Life** ● Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. *(secondary to HS-ESS1-1)*	
	Acquisition	
	Students will know… ● How the Sun generates energy through nuclear fusion it its core ● Stellar magnitude and color index allow astronomers to understand the physical properties of stars and predict their evolution ● Stars of different masses have very different evolutions and end their lives in a variety of ways (white dwarf, neutron star, black hole) ● **CCC: Scale, Proportion, and Quantity -** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. ● **CCC: Energy and Matter -** In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	*Students will be skilled at…* ● Analyzing and evaluating journal articles which address various astronomical topics and writing concise yet accurate article summaries ● Describing the overall properties of the Sun and discussing how the Sun generates energy through nuclear fusion in its core ● Explaining how the stellar magnitude system is used to provide a baseline for astronomical studies ● Describing how the color index of a star is determined and what information it provides about the physical properties of a star ● Comparing and contrasting how stars of different masses are created, evolve and die ● Using the Hertzsprung-Russell diagram to plot physical characteristics of stars, identifying where the main sequence is located and explaining why stars evolve off the main sequence ● Explaining the nature and origin of pulsars

		• Describing how black holes are formed and their effects on matter and radiation in their vicinity

Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
T, M, A	Rubric focused on content, accuracy, synthesis of concepts and reflection	PERFORMANCE TASK(S): *Students will show that they really understand evidence of…* *How stars of different masses go through their life cycles and produce elements heavier than hydrogen through nuclear fusion during various stages of their lives.* **Goal:** To create a book outlining the lives of stars to be used for educational purposes at a middle school **Role:** Children's Book Author **Audience:** Middle School Readers **Situation:** You have been asked by your publisher to write a book on the lives of stars targeting to a middle school audience **Product or Performance:** Fiction or Non-fiction book outlining the life cycle of a particular star **Standards for Success:** Rubric
		OTHER EVIDENCE: *Students will show they have achieved Stage 1 goals by…* • Quizzes and Tests • Formative assessments • Lab analysis and reflection on results • Warm-ups and exit tickets • Article readings/summaries • Homework assignments

Stage 3 – Learning Plan		
Code	***Pre-Assessment*** ● Brainstorming at the start of the unit ● Informal assessment of prior knowledge ● Developing questions related to upcoming unit	
	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring
M, A	**Teacher prepares notes and leads class discussions** - to introduce unit, provide content, provide opportunity formative assessment, and address misconceptions (E3)	● Quizzes on content ● Questions on activities and projects ● Verbal questions for comprehension ● End of Unit assessment
T, A	**Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries (E2, E4, E5)) Ex: Science Daily	
M, A	**Stellar Magnitude Lab** - students explore the concept of stellar magnitude and use it to predict distances of stars in the Milky Way (E2, E3)	
T, M, A	**H-R Diagram Lab** - students plot values for the nearest stars and brightest stars in the sky and use their results to make generalizations about stellar properties (E2, E4, E5))	

Unit 6: Galaxies and Cosmology

Phenomenon: Hubble Ultra Deep Field Image

Stage 1 Desired Results

ESTABLISHED GOALS

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

CCSS.ELA-LITERACY.RST 11-12.2: Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler, but still accurate terms

CCSS.ELA-LITERACY.RST 11-12.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in text

CCSS.ELA-LITERACY.RST 11-12.4: Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and

Transfer

Students will be able to independently use their learning to…

- SEP 1 - Ask questions
- SEP 2 - Develop and use models
- SEP 6 - Construct explanations

Meaning

UNDERSTANDINGS

Students will understand that…

ESS1.A: The Universe and Its Stars

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2)
- The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave

ESSENTIAL QUESTIONS

Students will keep considering…

How are physical laws used to explain and predict the motions of objects in space?

How does electromagnetic radiation make it possible to study objects which are too distant to visit?

How has technology been used to increase our knowledge and understanding of the universe?

What are some of the most important discoveries in astronomy and who are the scientists credited with these

topics	background) that still fills the universe. (HS-ESS1-2) ● Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2) **PS4.B: Electromagnetic Radiation** ● Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary to HS-ESS1-2)*	discoveries? What methods make it possible to determine the evolutionary stages and ages of the Earth, sun and universe? What is the origin and fate of the universe?
	Acquisition	
	Students will know… ● Galaxies are gargantuan collections of stellar and non-stellar matter ● Galaxies are categorized according to Hubble's system of classification; the Milky Way is classified as a spiral galaxy ● Galaxies with active cores produce measurable phenomena such as quasars which are the result of voracious supermassive black holes in their cores ● The implications of the cosmological principle; the universe is homogeneous and isotropic, which means there is no center and no edge ● The Big Bang occurred approximately 13.7 billion years ago and the universe has been expanding ever since	*Students will be skilled at…* ● Analyzing and evaluating journal articles which address various astronomical topics and writing concise yet accurate article summaries ● Describing the overall structure of the Milky Way Galaxy ● Describing the basic properties of the main types of normal galaxies and specifying the basic differences between active and normal galaxies ● Exploring the concept of stellar magnitude and using it to predict distances of stars in the Milky Way

	● Studies of visible matter, Dark Matter and Dark Energy have indicated that the universe is accelerating in its expansion and will likely continue to expand forever ● **CCC: Interdependence of Science, Engineering, and Technology -** Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. ● **CCC: Energy and Matter -** Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems.	● Re-creating the experiments by Hubble which determined the Andromeda Galaxy (and others) were located well outside the Milky Way ● Stating the cosmological principle and explaining its significance ● Explaining how the age of the universe is determined ● Discussing the factors that determine whether the universe will expand forever ● Modeling the expansion of the universe using Hubble's Law ● Summarizing the process of cosmic evolution as it's currently understood

Stage 2 – Evidence		
Code	**Evaluative Criteria**	**Assessment Evidence**
M, A	Rubric focusing on content, format, calculations and reflection.	PERFORMANCE TASK(S): *Students will show that they really understand evidence of…* *The methods used to determine the true scale and scope of the cosmos beyond our Milky Way galaxy.* **Goal:** To demonstrate to other astronomers the true scale of the universe **Role:** Edwin Hubble's Assistant **Audience:** Astronomical Society Members **Situation:** Your boss (Hubble) has asked you to present your findings to the astronomical society about the true distance of the Andromeda Galaxy from the Milky Way **Product or Performance:** Report to the astronomical society with calculations, analysis and conclusions drawn from your experiment **Standards for Success:** Rubric
		OTHER EVIDENCE: *Students will show they have achieved Stage 1 goals by…* ● Quizzes and Tests ● Formative assessments ● Lab analysis and reflection on results ● Warm-ups and exit tickets ● Article readings/summaries ● Homework assignments

Stage 3 – Learning Plan		
Code	***Pre-Assessment*** ● Brainstorming at the start of the unit ● Informal assessment of prior knowledge ● Developing questions related to upcoming unit	
	Summary of Key Learning Events and Instruction *Student success at transfer meaning and acquisition depends on…*	Progress Monitoring
M, A	**Teacher prepares notes and leads class discussions** - to introduce unit, provide content, provide opportunity formative assessment, and address misconceptions (E1, E3)	● Quizzes on content ● Questions on activities and projects ● Verbal questions for comprehension ● End of Unit assessment
T, A	**Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries (E2, E4, E5) Ex: Science Daily	
T, M, A	**Hubble's Law Lab** - students use Hubble's Law to model the expansion of the universe (E2, E4, E5)	