NEW MILFORD PUBLIC SCHOOLS
New Milford, Connecticut

Astronomy College Prep

June 2015

BOE Approved June 2016

New Milford Board of Education

David Lawson, Chairperson
Bill Dahl, Vice Chairperson
Wendy Faulenbach, Secretary
Tammy McInerney, Assistant Secretary
Angelia Chastain
Robert Coppola
David Littlefield
Brian McCauley
J.T. Schemm

Superintendent of Schools
Mr. Joshua Smith

Acting Assistant Superintendent
Dr. Genie Slone

New Milford High School Principal
Greg P. Shugrue

Authors of Course Guide
Danielle Ragonnet

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

In this semester course, students will explore the universe and discover unseen worlds. Major topics of this course include constellations and the celestial sphere, motion in space, 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 Environmental Earth Science.

Astronomy College Prep
Pacing Guide

		Number of weeks
Unit 1	Foundations of Astronomy	10
Unit 2:	Earth and Planetary Systems	3
Unit 3:	Stellar Processes and Systems	4
Unit 4:	Frontiers of Astronomy	3

Key for National and State Standards

HS-PS = Next Generation Science Standards: Physical Sciences

HS-ES = Next Generation Science Standards: Earth Sciences

HS-ETS = Next Generation Science Standards: Engineering, Technology, and Applications of Science

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

New Milford Public Schools
Curriculum Template

Committee Member: Danielle Ragonnet Unit Title: Foundations of Astronomy	Course/Subject: Astronomy Grade Level: 11-12 # of Weeks: 10

Identify Desired Results

Next Generation Science Standards and Common Core Standards

- **HS-ESS1-4.** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
- **HS-PS2-1.** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- **HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- **HS-PS4-2.** Evaluate questions about the advantages of using a digital transmission and storage of information.
- **HS-PS4-3.** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
- **HS-PS4-4.** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
- **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.RST11-12.2** 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.RST11-12.3** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
- **CCSS.ELA-LITERACY.RST11-12.4** 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.RST11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

Enduring Understandings Generalizations of desired understanding via essential questions (Students will understand that ...)	Essential Questions Inquiry used to explore generalizations
• Physical laws can be used to explain and predict the motions of objects in the universe. • Electromagnetic radiation transmits information about otherwise inaccessible objects. • Technologies such as telescopes, satellites and spacecraft have contributed greatly to the knowledge and exploration of the universe. • Key scientific discoveries have led to our current understanding of the nature of the universe.	• 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 discoveries?

Expected Performances
What students should know and be able to do

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
- 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
- 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
- Analyzing the full spectrum of electromagnetic radiation from an object provides valuable insight about processes which are invisible

Students will be able to do the following:

- Analyze and evaluate journal articles which address various astronomical topics and write concise yet accurate article summaries
- Explain the concept of the celestial sphere and the use of angular measurement to locate objects in the sky
- Describe how and why the Sun, Moon and stars appear to change position from night to night and month to month
- Explain how clocks and calendars are linked to Earth's rotation and orbit around the Sun
- Show how the relative motions of Earth, the Sun and the Moon lead to lunar phases and eclipses
- Explain the simple geometric reasoning that allows astronomers to measure the distances and sizes of otherwise inaccessible objects
- Apply what they know about celestial coordinates to use a planisphere to locate objects in the sky
- Apply their knowledge of the relative positions of sun, moon and Earth to

accurately construct a lunar phase diagram
- Summarize the role of Renaissance science in the history of astronomy
- Create a biographical presentation outlining the accomplishments of a notable astronomer
- State Kepler's laws of planetary motion and explain how Kepler's laws allow us to construct a scale model of the solar system
- State Newton's laws of motion and universal gravitation and explain how they account for Kepler's laws
- Explain how the law of gravitation enables us to measure the masses of astronomical bodies
- Re-create the experiment conducted by Eratosthenes which accurately measured the circumference of the Earth around 200BC
- Validate Kepler's Third Law of Planetary Motion by applying modern values for the orbital periods and distances of the planets in the solar system
- Discuss the nature of electromagnetic radiation and how radiation transfers energy and information through interstellar space
- Describe the characteristics of spectra and the conditions under which they are produced and explain the kinds of information that can be obtained by analyzing the spectra of astronomical objects
- Observe and draw the emission spectra of several gases and use the results to predict the composition of overhead fluorescent lamps
- Sketch and describe the basic designs of the major types of optical telescopes
- Describe how Earth's atmosphere affects astronomical observations and discuss some of the current efforts to improve ground-based astronomy
- Discuss the advantages and disadvantages of radio astronomy compared with optical observations
- Explain why some observations are best done from space, and discuss the advantages and limitations of space-based astronomy
-

Character Attributes

- Respect
- Responsibility
- Honesty
- Integrity
- Cooperation
- Perseverance

Technology Competencies

- Use of refracting and reflecting telescopes
- Use of spectroscopes
- Word processing, spreadsheet and presentation software

Develop Teaching and Learning Plan

Teaching Strategies:

- Provide guided note sheets when necessary
- Cooperative group work
- Modeling of objects and systems
- Unit outlines and study guides
- Multimedia presentations of material
- Questioning techniques (no opt out, right is right, etc.)

Learning Activities:

- **Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries
- **Using a Planisphere Lab** - students use what they know about celestial coordinates and a planisphere to locate objects in the sky
- **Lunar Phases Lab** - students use their knowledge of the relative positions of sun, moon and Earth to accurately construct a lunar phase diagram
- **Parallax Lab** - students use the principle of parallax to indirectly measure the length of their outstretched arm
- **Eratosthenes Measures Earth Lab** - students re-create the experiment conducted by Eratosthenes which accurately measured the circumference of the Earth around 200BC
- **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.
- **Spectroscopy Lab** - students observe and draw the emission spectra of several gases and use their results to predict the

	composition of overhead fluorescent lamps • **In-class Trip to Observatory** - students will be introduced to the observatory's facilities and be given an opportunity to view the Sun in the telescope

Assessments

Performance Task(s) Authentic application to evaluate student achievement of desired results designed according to GRASPS (one per marking period)	**Other Evidence** Application that is functional in a classroom context to evaluate student achievement of desired results
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	• Quizzes • Unit Tests • Formative Assessments • Lab Analysis Questions • Article Summaries • Projects and Presentations • Questioning and Discussion

Suggested Resources

- Chaisson, Eric, and S. McMillan. *Astronomy Today*. 5th ed. San Francisco, CA: Pearson / Addison Wesley, 2005. Print.
- Hirshfeld, Alan W. *Astronomy: Activity and Laboratory Manual*. Sudbury, Mass: Jones & Bartlett Pub, 2008. Print.

New Milford Public Schools
Curriculum Template

Committee Member: Danielle Ragonnet Unit Title: Earth and Planetary Systems	Course/Subject: Astronomy Grade Level: 11-12 # of Weeks: 3

Identify Desired Results

Next Generation Science Standards and Common Core Standards

- **HS-ESS1-4.** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
- **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.
- **HS-PS1-8.** 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.
- **HS-PS2-1.** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- **HS-PS2-4.** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
- **HS-PS4-4.** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
- **HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- **HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- **HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- **CCSS.ELA-LITERACY.RST11-12.2** 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.RST11-12.3** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.

- **CCSS.ELA-LITERACY.RST11-12.4** 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.RST11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- **CCSS.ELA-LITERACY.RST11-12.9** 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.

Enduring Understandings Generalizations of desired understanding via essential questions (Students will understand that ...)	**Essential Questions** Inquiry used to explore generalizations
• Physical laws can be used to explain and predict the motions of objects in the universe. • Electromagnetic radiation transmits information about otherwise inaccessible objects. • Technologies such as telescopes, satellites and spacecraft have contributed greatly to the knowledge and exploration of the universe. • Studying other objects and systems in the universe provide valuable information about the formation, evolution and fate of Earth. • According to the latest findings, the solar system formed approximately 4.6 billion years ago from a cloud of gas and dust. • If life does exist elsewhere in the universe, it will form within the constraints of physical, chemical and biological laws.	• 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 methods make it possible to determine the evolutionary stages and ages of the Earth, Sun and universe? • How is Earth similar to and different from the other planets in the solar system?

Expected Performances
What students should know and be able to do

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
- There have been dozens of space exploration missions which have provided valuable insights into the nature 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

Students will be able to do the following:

- Summarize the basic differences between the terrestrial and Jovian planets
- Identify and describe the major non-planetary components of the solar system
- Describe some satellites and spacecraft missions that have contributed significantly to our knowledge of the solar system
- Discuss the origin of the solar system
- Assemble a scale model of the solar system
- Use computer simulation software to model radioactive decay and use the findings to discuss how the age of the Earth was determined
- Create a plan for building a resort hotel on or around an object in the solar system

Character Attributes

- Respect
- Responsibility
- Honesty
- Integrity
- Cooperation
- Perseverance

Technology Competencies

- Computer modeling of radioactive decay
- Word processing, spreadsheet and presentation software

Develop Teaching and Learning Plan

Teaching Strategies:	Learning Activities:
• Provide guided note sheets when necessary • Cooperative group work • Modeling of objects and systems • Unit outlines and study guides • Multimedia presentations of material	• **Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries • **In-Class Visit to Observatory** - students are introduced to some of

• Questioning techniques (no opt out, right is right, etc.)	the most notable solar system exploration missions (Martian Rovers, New Horizons, Voyager, etc.) • **Solar System Modeling Activity** - students will assemble a scale model of the solar system (football field 1st semester, hallway 2nd semester) • **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 • **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

Assessments	
Performance Task(s) Authentic application to evaluate student achievement of desired results designed according to GRASPS (one per marking period)	**Other Evidence** Application that is functional in a classroom context to evaluate student achievement of desired results
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	• Quizzes • Unit Tests • Formative Assessments • Lab Analysis Questions • Article Summaries • Projects and Presentations • Questioning and Discussion

Suggested Resources

- Chaisson, Eric, and S. McMillan. *Astronomy Today*. 5th ed. San Francisco, CA: Pearson / Addison Wesley, 2005. Print.
- Hirshfeld, Alan W. *Astronomy: Activity and Laboratory Manual*. Sudbury, Mass: Jones & Bartlett Pub, 2008. Print.
-

New Milford Public Schools
Curriculum Template

Committee Member: Danielle Ragonnet Unit Title: Stellar Processes and Systems	Course/Subject: Astronomy Grade Level: 11-12 # of Weeks: 4

Identify Desired Results

Next Generation Science Standards and Common Core Standards

- **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.
- **HS-PS1-8.** 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.
- **HS-PS2-1.** Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- **HS-PS2-4.** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
- **HS-PS3-1.** 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.
- **HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- **HS-PS4-2.** Evaluate questions about the advantages of using a digital transmission and storage of information.
- **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.
- **HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- **HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- **HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and

environmental impacts.

- **CCSS.ELA-LITERACY.RST11-12.2** 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.RST11-12.3** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
- **CCSS.ELA-LITERACY.RST11-12.4** 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.RST11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- **CCSS.ELA-LITERACY.RST11-12.9** 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.

Enduring Understandings Generalizations of desired understanding via essential questions (Students will understand that ...)	**Essential Questions** Inquiry used to explore generalizations
• Electromagnetic radiation transmits information about otherwise inaccessible objects. • Technologies such as telescopes, satellites and spacecraft have contributed greatly to the knowledge and exploration of the universe. • Studying other objects and systems in the universe provide valuable information about the formation, evolution and fate of Earth. • The process of nucleosynthesis in stars is responsible for the creation of the heavier elements currently found in the universe. • Stars of different masses have several key evolutionary differences and end their lives in manners	• 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 methods make it possible to determine the evolutionary stages and ages of the Earth, Sun and universe? • What is meant when it is said we are all made of star stuff? • Is our Sun a "typical" star?

specific to their starting mass. • Key scientific discoveries have led to our current understanding of the nature of the universe. • No system is eternal; planetary systems, stars and galaxies all begin, evolve and die leaving materials to be recycled into new systems.	

Expected Performances
What students should know and be able to do

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)
- 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 super-massive black holes in their cores

Students will be able to do the following:

- Describe the overall properties of the Sun and discuss how the Sun generates energy through nuclear fusion in its core
- Explain how the stellar magnitude system is used to provide a baseline for astronomical studies
- Describe how the color index of a star is determined and what information it provides about the physical properties of a star
- Compare and contrast how stars of different masses are created, evolve and die
- Use the Hertzsprung-Russell diagram to plot physical characteristics of stars, identify where the main sequence is located and explain why stars evolve off the main sequence
- Explain the nature and origin of pulsars
- Describe how black holes are formed and their effects on matter and radiation in their vicinity
- Describe the overall structure of the Milky Way Galaxy
- Describe the basic properties of the main types of normal galaxies and specify the basic differences between active and normal galaxies
- Use knowledge of observation protocols and imaging software to conduct an investigation and report on it
- Explore the concept of stellar magnitude and use it to predict distances of stars in

the Milky Way
- Re-create the experiments by Hubble which determined the Andromeda Galaxy (and others) were located well outside the Milky Way

Character Attributes

- Respect
- Responsibility
- Honesty
- Integrity
- Cooperation
- Perseverance

Technology Competencies

- Use of reflecting and refracting telescopes
- Imaging software for processing telescope data
- Computer-based spreadsheet and graphing software
- CCD (Charged Coupled Device) Camera
- Word processing, spreadsheet and presentation software

Develop Teaching and Learning Plan

Teaching Strategies:

- Provide guided note sheets when necessary
- Cooperative group work
- Modeling of objects and systems
- Unit outlines and study guides
- Multimedia presentations of material
- Questioning techniques (no opt out, right is right, etc.)

Learning Activities:

- **Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries
- **In-Class Visit to Observatory** - students will be introduced to observatory's imaging software and observation protocols
- **Night-time Visit to Observatory** - students will use knowledge of observation protocols and imaging software to conduct an investigation and report on it
- **Stellar Magnitude Lab** - students explore the concept of stellar magnitude and use it to predict distances of stars in the Milky Way
- **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

	• **Realm of Spiral Nebulae Lab** - students re-create the experiments by Hubble which determined the Andromeda Galaxy (and others) were located well outside the Milky Way

Assessments	
Performance Task(s) Authentic application to evaluate student achievement of desired results designed according to GRASPS (one per marking period)	**Other Evidence** Application that is functional in a classroom context to evaluate student achievement of desired results
Goal: Use the observatory to conduct a scientific investigation and write a report on your findings for publication in a well-known scientific journal **Role:** Astronomer **Audience:** Scientific journal **Situation:** You will choose a relevant topic to research at the observatory and communicate your methods and findings in a formal research paper. **Product or Performance:** A formal research paper outlining methods and findings **Standards for Success:** Rubric	• Quizzes • Unit Tests • Formative Assessments • Lab Analysis Questions • Article Summaries • Projects and Presentations • Questioning and Discussion

Suggested Resources

- Chaisson, Eric, and S. McMillan. *Astronomy Today*. 5th ed. San Francisco, CA: Pearson / Addison Wesley, 2005. Print.
- Hirshfeld, Alan W. *Astronomy: Activity and Laboratory Manual*. Sudbury, Mass: Jones & Bartlett Pub, 2008. Print.

New Milford Public Schools
Curriculum Template

Committee Member: Danielle Ragonnet Unit Title: Frontiers of Astronomy	Course/Subject: Astronomy Grade Level: 11-12 # of Weeks: 3

Identify Desired Results

Next Generation Science Standards and Common Core Standards

- **HS-ESS1-2.** Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
- **HS-PS2-4.** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
- **HS-PS3-1.** 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.
- **HS-PS4-1.** Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- **HS-PS4-2.** Evaluate questions about the advantages of using a digital transmission and storage of information.
- **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.
- **HS-ETS1-1.** Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- **HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.
- **CCSS.ELA-LITERACY.RST11-12.1** 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.RST11-12.2** 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.RST11-12.3** Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
- **CCSS.ELA-LITERACY.RST11-12.4** 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.RST11-12.7** Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- **CCSS.ELA-LITERACY.RST11-12.8** Evaluate the hypotheses, data, analysis, 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.RST11-12.9** 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.

Enduring Understandings Generalizations of desired understanding via essential questions (Students will understand that ...)	**Essential Questions** Inquiry used to explore generalizations
• Physical laws can be used to explain and predict the motions of objects in the universe. • Electromagnetic radiation transmits information about otherwise inaccessible objects. • Technologies such as telescopes, satellites and spacecraft have contributed greatly to the knowledge and exploration of the universe. • Studying other objects and systems in the universe provide valuable information about the formation, evolution and fate of Earth. • Key scientific discoveries have led to our current understanding of the nature of the universe. • If life does exist elsewhere in the universe, it will form within the constraints of physical, chemical and biological laws. • According to the latest findings, the universe formed approximately 13.7	• 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 methods make it possible to determine the evolutionary stages and ages of the Earth, Sun and universe? • What is the fate of the universe? • What are some of the most important discoveries in astronomy and who are the scientists credited with these discoveries?

billion years ago in the Big Bang and has been expanding ever since. • No system is eternal; planetary systems, stars and galaxies all begin, evolve and die leaving materials to be recycled into new systems.	

Expected Performances
What students should know and be able to do

Students will know:

- 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 every since
- 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
- The chemistry of life is found throughout the cosmos but no evidence of life elsewhere has been discovered yet
- The Drake Equation speculates on the potential number of intelligent, technological civilizations which might exist in the Milky Way
- Hundreds of exoplanets have been discovered since the 1990s using a variety of techniques

Students will be able to do the following:

- State the cosmological principle and explain its significance
- Explain how the age of the universe is determined
- Discuss the factors that determine whether the universe will expand forever
- Model the expansion of the universe using Hubble's Law
- Summarize the process of cosmic evolution as it's currently understood
- Evaluate the chances of finding life elsewhere in the solar system
- Summarize how we estimate the number of advanced civilizations that might exist in the galaxy
- Discuss some of the techniques we might use to search for and communicate with extraterrestrials
- Explore methods used to detect exoplanets

Character Attributes

- Respect
- Responsibility
- Honesty
- Integrity
- Cooperation
- Perseverance

Technology Competencies
• Word processing, spreadsheet and presentation software • Database search engine use for research

Develop Teaching and Learning Plan

Teaching Strategies:	Learning Activities:
• Provide guided note sheets when necessary • Cooperative group work • Modeling of objects and systems • Unit outlines and study guides • Multimedia presentations of material • Questioning techniques (no opt out, right is right, etc.)	• **Astronomy Article Summaries** - students read journal articles which address various astronomical topics and write concise yet accurate article summaries • **Hubble's Law Lab** - students use Hubble's Law to model the expansion of the universe • **Life in the Universe Activity** - students will be introduced to the field of astrobiology and use certain physical laws to predict the type of life likely to be found in different environments • **Exoplanet Activity** - students will explore methods used to detect exoplanets and write a profile on one exoplanetary system

Assessments

Performance Task(s) Authentic application to evaluate student achievement of desired results designed according to GRASPS (one per marking period)	**Other Evidence** Application that is functional in a classroom context to evaluate student achievement of desired results
Goal: Write an argumentative essay about the use of government funds to search for the existence of life elsewhere in the universe. **Role:** Writer for the school paper **Audience:** High school students **Situation:** You've been asked to write an essay outlining the opposing points of view regarding the use of public funds to research the existence of extraterrestrial life. **Product or Performance:** An argumentative essay that takes a stance in	• Quizzes • Unit Tests • Formative Assessments • Lab Analysis Questions • Article Summaries • Projects and Presentations • Questioning and Discussion

the debate about the use of government funds to search for the existence of life elsewhere in the universe. **Standards for Success:** Rubric	

Suggested Resources

- Chaisson, Eric, and S. McMillan. *Astronomy Today*. 5th ed. San Francisco, CA: Pearson / Addison Wesley, 2005. Print.
- Hirshfeld, Alan W. *Astronomy: Activity and Laboratory Manual*. Sudbury, Mass: Jones & Bartlett Pub, 2008. Print.
-