Randolph Township Schools
Randolph High School

High School Astronomy Curriculum

"Somewhere, something incredible is waiting to be known."
Carl Sagan

STEM Department
Michael Cascione, Supervisor

Curriculum Committee
Andrew Palmer
Rick Howe

Curriculum Developed:
June 27, 2017

Date of Board Approval:
October 17, 2017

Randolph Township Schools
STEM Department
Astronomy

Table of Contents

Randolph Township Schools

Mission Statement

We commit to inspiring and empowering all students in Randolph schools to reach their full potential as unique, responsible and educated members of a global society.

Randolph Township Schools
Affirmative Action Statement

Equality and Equity in Curriculum

The Randolph Township School district ensures that the district's curriculum and instruction are aligned to the state's standards. The curriculum provides equity in instruction, educational programs and provides all students the opportunity to interact positively with others regardless of race, creed, color, national origin, ancestry, age, marital status, affectional or sexual orientation, gender, religion, disability or socioeconomic status.

N.J.A.C. 6A:7-1.7(b): Section 504, Rehabilitation Act of 1973; N.J.S.A. 10:5; Title IX, Education Amendments of 1972

RANDOLPH TOWNSHIP BOARD OF EDUCATION
EDUCATIONAL GOALS
VALUES IN EDUCATION

The statements represent the beliefs and values regarding our educational system. Education is the key to self-actualization, which is realized through achievement and self-respect. We believe our entire system must not only represent these values, but also demonstrate them in all that we do as a school system.

We believe:

- The needs of the child come first
- Mutual respect and trust are the cornerstones of a learning community
- The learning community consists of students, educators, parents, administrators, educational support personnel, the community and Board of Education members
- A successful learning community communicates honestly and openly in a non-threatening environment
- Members of our learning community have different needs at different times. There is openness to the challenge of meeting those needs in professional and supportive ways
- Assessment of professionals (i.e., educators, administrators and educational support personnel) is a dynamic process that requires review and revision based on evolving research, practices and experiences
- Development of desired capabilities comes in stages and is achieved through hard work, reflection and ongoing growth

Randolph Township Schools
STEM Department

Astronomy

Introduction

This is a semester elective course designed for high school students interested in studying astronomy. Astronomy studies all aspects of the known universe, an observational science that has transformed over the ages as new models, ideas, and instruments are introduced. This curriculum models the Science New Jersey Student Learning Standards - where inquiry based learning is encouraged to best support students with educational tools and allow them to develop their own scientific lens.

The main topics of the course are:

- The solar system - history of understanding the solar system and universe, the planets and their moons, asteroids, and comets.
- Stars and stellar evolution - stellar birth and the formation of planets, stellar death, including neutron stars, black holes, and supernovae.
- Galaxies - galaxy classification, quasars, supermassive black holes, and dark matter.
- Cosmology - the expansion of the universe, its origin in the Big Bang, dark energy and the future of the universe.
- Current Explorations - recent missions that have explored many areas of the universe.

The course emphasizes the physical processes at work in the universe and the methods we use to learn about the universe.

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Curriculum Pacing Chart
Astronomy

SUGGESTED TIME ALLOTMENT	UNIT NUMBER	CONTENT - UNIT OF STUDY
4 weeks	**I**	**Big Bang and Electromagnetic Radiation**
4 weeks	**II**	**History of Astronomy**
4 weeks	**III**	**Stellar Evolution**
4 weeks	**IV**	**Planets and The Solar System**
2 weeks	**V**	**Current-Day Exploration**

RANDOLPH TOWNSHIP SCHOOL DISTRICT

Astronomy

UNIT I: Big Bang and Electromagnetic Radiation (EMR)

TRANSFER: Relate common, everyday uses of electromagnetic radiation to understanding astronomical findings.

STANDARDS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-ESS1-2: Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1.A: 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 background) that still fills the universe. HS-ESS1-2: Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.	The origins of all elements rely on the Big Bang Theory.	• How does astronomy answer the question: "What are we made of, and where do we come from?"
	All objects in the universe influence one another.	• How big is "big" and how long is a "long time?"
	Electromagnetic radiation is the key to studying the universe and its constant evolution.	• How is light used as a remote sensing tool to understand the universe?
	KNOWLEDGE	**SKILLS**
	Students will know: Various forms of EMR are used to analyze astronomical objects. The Doppler Effect can be used to determine the relative motion of astronomical objects.	**Students will be able to:** Use equations related to EMR to determine the characteristics of celestial objects. Construct laboratory equipment to analyze different sources of electromagnetic radiation and their spectra.

	Origins of the universe and its evolution are best explained by the Big Bang Theory. **VOCABULARY/KEY TERMS:** Astronomical units, scientific notation, galaxy, parallax**,** Big Bang, Electromagnetic Radiation, Spectroscopy, Doppler Effect	Evaluate and determine characteristics of moving sources of electromagnetic radiation in the universe.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Analyzing different spectral sources
- Creating visual representations of EMR sources
- Modelling astronomical scale

KEY LEARNING EVENTS AND INSTRUCTION:

- Build spectroscope
- Analyze raw data from NASA

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Astronomy
Unit I: Big Bang and Electromagnetic Radiation (EMR)

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
4 Weeks	**Big Bang and Electromagnetic Radiation (EMR)** ● Basic characteristics of EMR (wavelength, frequency, velocity) ● Different sources of EMR ● Uses and measurement of EMR ● Size and history of the universe ● Evidence for Big Bang Theory	Astronomy Today, Eric Chaisson Project Star Activities Space, Delta Science Readers **Space** http://www.swpc.noaa.gov/index.html

RANDOLPH TOWNSHIP SCHOOL DISTRICT

Astronomy
UNIT 2: The History of Astronomy

TRANSFER: Scientific understandings are scaffolded upon previous theories and new discoveries.

STANDARDS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS–ESS1-4: 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-ESS1-2: A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	Mass, distance, and time are measured using mathematical models.	● Given our limitations of space travel, how do we know so much about space and the universe?
	Scientific theories evolve over time as new evidence becomes available.	● How has our understanding of space and the universe changed over time?
	We live in a local group within a spiral arm of the Milky Way Galaxy.	● Where are we in the universe?
	KNOWLEDGE	**SKILLS**
	Students will know: The model of our solar system developed through the observations of many scientists. The heliocentric model best explains our solar system.	**Students will be able to:** Describe the contributions of scientists to the heliocentric model of the solar system. Explain how new evidence obtained by using telescopes allowed 17th century astronomers to displace the geocentric model of the universe.

HS-ESS1-2: Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.	Gravitation is a universal force that each mass exerts on any other mass. The motions of celestial objects can be predicted by mathematical laws of science. **VOCABULARY/KEY TERMS:** Geocentric vs. Heliocentric, retrograde motion, Kepler's Laws, Newton's Laws, gravity, orbit, Ptolemy/Copernicus/Galileo/Brahe/Kepler/Newton	Demonstrate how gravity acts upon two objects Calculate and predict the position and motion of celestial bodies using Newton's Laws of Motion and Kepler's Laws.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Collaborative timeline of scientific discoveries
- Plot orbit of Mars using Kepler's data
- Present biography of important astronomers

KEY LEARNING EVENTS AND INSTRUCTION:

- Field trip to Hayden Planetarium
- Analyze actual data from astronomical observations

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Astronomy
Unit 2: History of Astronomy

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
4 Weeks	**History of Astronomy** ● Geocentric vs. Heliocentric models ● Timeline of astronomical scientific discoveries ● Tools of measurement ● Evidence to support heliocentric model ● Kepler's and Newton's Laws	Astronomy Today, Eric Chaisson Project Star Activities Space, DeltaScienceReaders Nasa.gov

RANDOLPH TOWNSHIP SCHOOL DISTRICT

Astronomy
Unit 3: Stellar Evolution

TRANSFER: Students will be exposed to the challenges that future generations will experience as our sun evolves.

STANDARDS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-ESS1-1: The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. HS-ESS1-2: 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: 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.	Stars have a "life" cycle.	• What is the fate of our sun?
	Stellar composition is determined by spectral analysis.	• How do we know what stars are made of?
	The HR-Diagram is used to compare stars.	• What characteristics determine the evolutionary path of a star?
	KNOWLEDGE	**SKILLS**
	Students will know: A star's mass determines its evolutionary path. Each star's stellar spectrum is a fingerprint used to identify its composition. Identifying characteristics of various star types can be compared by plotting them on the HR-Diagram.	**Students will be able to:** Diagram the life cycle of stars. Analyze stellar spectra to determine composition. Compare and contrast stars using the HR-Diagram.

	VOCABULARY/KEY TERMS: Protostar, main sequence, red giant/supergiant, nova/supernova, white dwarf, black dwarf, neutron star, black hole, HR-Diagram, luminosity, temperature, mass, spectra	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Plotting stellar data on the HR-Diagram
- Predicting the outcome of a particular star based on its characteristics

KEY LEARNING EVENTS AND INSTRUCTION:

- Analyzing the life-cycle of our Sun
- Drawing and interpreting HR-Diagrams

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Astronomy
Unit 3: Stellar Evolution

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
4 Weeks	**Stellar Evolution** ● Characteristics of various classifications of stars ● Analyzing stellar spectra (EMR) ● Plotting data on HR-Diagrams ● Comparing stars and their stellar evolutions	Astronomy Today, Eric Chaisson Project Star Activities Space, Delta Science Readers Stellar Evolution and HR Diagram www.astunit.com/tutorials/ stellar.htm Stellar Evolution and HR Diagram www.cass.ucsd.edu/public/tutorial/StevI.html

RANDOLPH TOWNSHIP SCHOOL DISTRICT

Astronomy
Unit 4: Planets and The Solar System

TRANSFER: Understanding the conditions that led to life on Earth helps predict where other life-sustaining exoplanets may exist.

STANDARDS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
ESS1.B: 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.	The solar nebular theory explains the current understanding of the formation of the solar system.	• How does the theory of the solar system's origin explain its observed properties?
	Water is not rare in space; liquid water is rare.	• What are the life-sustaining characteristics of a planet?
	Tidal influences from both the moon and sun impact the evolution of life on Earth.	• What would change about Earth if the moon did not exist?
HS-ESS1-6: 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.	**KNOWLEDGE**	**SKILLS**
	Students will know: The properties and characteristics of solar system objects, combined with radioactive dating of meteorites and lunar samples, provide evidence to support the solar nebular theory. Planet characteristics depend on various factors such as temperature, distance from the sun, and composition.	**Students will be able to:** Collect, analyze, and critique evidence that supports the theory that the Earth, and the rest of the solar system, formed from a nebular cloud of dust and gas 4.6 billion years ago. Compare and contrast characteristics of the eight planets in our solar system.

HS-ESS1-4: 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).	The conditions that created a life-sustaining Earth are not unique in the universe, and have been observed in exoplanets. **VOCABULARY/KEY TERMS:** Sun, solar system, planet, exoplanet, atmosphere, Terrestrial vs. Jovian, Kuiper Belt, Oort Cloud, meteorites/asteroids/comets	Evaluate the geological and astronomical evidence of Earth's formation and evolution toward a life-sustaining environment.

ASSESSMENT EVIDENCE: Students will show their learning by:

- Build a scale model of the solar system
- Exoplanet report

KEY LEARNING EVENTS AND INSTRUCTION:

- Studying geocentric and heliocentric models
- Field trip to CCM Observatory

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Astronomy
Unit 4: Planets and The Solar System

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
4 Weeks	**Planets and The Solar System** ● Formation of Solar System ● Terrestrial vs. Jovian planets ● Life-Sustaining characteristics of a planet	Astronomy Today, Eric Chaisson Project Star Activities Space, Delta Science Readers

RANDOLPH TOWNSHIP SCHOOL DISTRICT

Astronomy
Unit 5: Current Day Exploration

TRANSFER: What role do we, as young scientists, play in the future of space exploration.

STANDARDS:	**ENDURING UNDERSTANDINGS**	**ESSENTIAL QUESTIONS**
HS-ESS1-4: Science and engineering complement each other in the cycle known as research and development (RandD). Many RandD projects may involve scientists, engineers, and others with wide ranges of expertise. HS-ESS1-3: Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). HS-ESS1-6: Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.	Various measurement tools are used to gain information regarding newly discovered exoplanets.	• How do we know if planets other than Earth can sustain life?
	Hostile environments on Earth have been shown to harbor life that are very different than normal conditions.	• Is an Earth-like environment the only type of environment capable of sustaining life?
	Earth and the solar system have a finite life-span and will not be here forever.	• Why should high school students care if life exists beyond Earth?
	KNOWLEDGE	**SKILLS**
	Students will know: Limitations and challenges exist in space that will negatively impact humans over the long term. The conditions for life are more varied – and more extreme – than originally thought by scientists. Current-day astronomical equipment are highly specialized based on their purpose and location.	**Students will be able to:** Design specialized equipment to help humans survive long periods of time in space. Evaluate parameters for sustaining life as we know it. Analyze the abilities, limitations, and variations of modern day astronomical measuring equipment.

	VOCABULARY/KEY TERMS: Telescope, satellite, launch vehicle, payload, sensor, remote sensing, rover, landers, orbiter, microgravity, carbon-based life forms	

ASSESSMENT EVIDENCE: Students will show their learning by:

- Presentation on modern-day missions
- Research and differentiate among various astronomical measuring equipment

KEY LEARNING EVENTS AND INSTRUCTION:

- Field trip to CCM Observatory
- Skype interview with astronomer

RANDOLPH TOWNSHIP SCHOOL DISTRICT
Astronomy
Unit 5: Current Day Exploration

SUGGESTED TIME ALLOTMENT	CONTENT-UNIT OF STUDY	SUPPLEMENTAL UNIT RESOURCES
2 Weeks	**Current Day Exploration** ● Current astronomical equipment used by modern-day astronomers ● Variety of telescopes and their uses ● Conversation with astronomer regarding the future of astronomy and space travel	Astronomy Today, Eric Chaisson Project Star Activities Space, DeltaScienceReaders