PISCATAWAY
TOWNSHIP SCHOOLS

**Dr. Frank Ranelli**
Superintendent of Schools
**Dr. William Baskerville**
Assistant Superintendent for
Curriculum and Instruction

# Astronomy

**Content Area:**
**Grade Span:** 11 & 12
**Revised by:** Erin Bontempo and Jessica Pritchard
**Presented by:** Jessica Pritchard
**Approval date:** August 12, 2021

**Members of the Board of Education**
Shelia Hobson – Board President
Kimberly Lane – Vice President
Shantell Cherry
Jeffrey Fields, Sr.
Ralph Johnson
Calvin Laughlin
Nitang Patel
Zoe Scotto
Brenda Smith

**Piscataway Township Schools**
1515 Stelton Road
Piscataway, NJ 08854-1332
732 572-2289, ext. 2561
Fax 732 572-1540
www.piscatawayschools.org

# COURSE OVERVIEW

## Description

This is an elective course in Astronomy for 2.5 credits, which explores cosmology from ancient concepts to current information about the moon, planets, stars, and galaxies. The formation and evolution of planets, stars, and the universe is also examined based on current scientific knowledge. This course emphasizes the seasonal changes observed in the night sky including constellations, stars, planets, and the sun and the moon. Instrumentations such as satellites, telescopes and spectroscopes will be studied along with techniques used to measure the size and distance of astronomical objects. Historical developments in astronomy will be explored. Some concepts studied are fundamental to science, such as understanding how the matter of our world formed during the Big Bang and within the cores of stars. Other concepts are practical, such as understanding how short term changes in the behavior of our sun directly affect humans. Engineering and technology play a large role here in obtaining and analyzing the data that support the theories of the formation of the solar system and universe. Students plan and conduct investigations and apply scientific ideas to explain all manner of phenomena in our galaxy and beyond.

## Goals

The course directs students to investigate the movements and composition of the physical universe using the laws of physics and chemistry and the application of mathematical skills such as graphing, geometry, trigonometry, and algebra through a variety of cross curricular modalities. The crosscutting concepts of patterns; scale, proportion, and quantity; energy and matter; and interdependence of science, engineering, and technology are called out as organizing concepts for these disciplinary core ideas. Students demonstrate proficiency in developing and using models; using mathematical and computational thinking, constructing explanations; and obtaining, evaluating, and communicating information; and to use these practices to demonstrate understanding of the core ideas.

## Scope and Sequence

| Unit | Topic | Length |
|---|---|---|
| 1 | Astronomy and The Universe | 18 days |
| 2 | Our Planetary System | 13 days |
| 3 | Stars and Stellar Evolution | 14 days |

# UNIT 1: ASTRONOMY AND THE UNIVERSE

## Summary and Rationale

In this unit, students focus on understanding the history of the study of the night sky. Students explore cosmology from ancient concepts to current data about the moon, planets and stars, and are therefore able to analyze the dynamic nature of astronomy by comparing and contrasting evidence supporting current views of the universe with historical views. Students investigate the motion of the night sky including the constellations, as preparation for the next unit of study about the properties and motions of other celestial bodies in our solar system.

## Recommended Pacing

18 days

## State Standards

| | |
|---|---|
| **HS-ESS 1-2 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.** | |
| Clarification Statement | Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium). |
| **HS-ESS 1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** | |
| Clarification Statement | Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons |
| Assessment Boundary | Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus. |
| **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.** | |
| Clarification Statement | Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields. |
| Assessment Boundary | Assessment is limited to systems with two objects. |

## Instructional Focus

**Unit Enduring Understandings (Cross Cutting Concepts)**

- Human understanding of the universe is changing as knowledge is acquired through the use of modern technologies.
- Observations of galaxy expansion, cosmic radiation and the Big Bang Theory describe an expanding universe about 14 billion years old.
- Radiation emitted or reflected by distant objects allows scientists to study the universe.
- The stars of the night sky were grouped long ago by human imagination into patterns called Constellations. Astrology and mythologies offer an understanding of the historical development of modern astronomy.
- The study of constellations provides a means to better recognize and predict the movement (rotation and revolution) of the Earth.

**Unit Essential Questions**

- How did early astronomers use the scientific method?
- How could one gather evidence to support that the solar system is heliocentric?
- Why do stars appear to move in the night sky?

**Objectives**

**Students will know (DCIs):**

- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distance from Earth.
- 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 the maps of spectra of the primordial radiation.
- 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.
- Newton's second law accurately predicts changes in the motion of macroscopic objects.

**Students will be able to (SEPs):**

- Construct an explanation based on valid and reliable evidence obtained from a variety of sources and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Use mathematical or computational model representations of phenomena to describe explanations.
- Recognize constellation patterns.
- Determine circumpolar constellations as a function of latitude.
- Predict the visibility of constellations based on the earth sun relationship. (seasonal)
- Research examples mythologies associated with the constellations and astrology (horoscopes and astrological signs).

# UNIT 2: OUR PLANETARY SYSTEM

## Summary and Rationale

This unit of study provides students the opportunity to develop knowledge and understanding about the planetary system in which we live. Students will develop an understanding of how our Solar System was formed. Students will explore connections between cosmic phenomena and conditions necessary for life, while also learning of the historical and recent missions to outer space and the challenges presented within those missions.

## Recommended Pacing

13 days

## State Standards

**HS-ESS 1-6 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.**

| | |
|---|---|
| Clarification Statement | Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces. |

**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-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**

## Instructional Focus

**Unit Enduring Understandings (Cross Cutting Concepts)**

- Using Newton's laws of motion and gravitation, astronomers can understand the orbits and the properties of the planets and other objects in the solar system.
- Human understanding of the universe is changing as knowledge is acquired through the use of modern technologies and coordination/information gathering on space missions.

**Unit Essential Questions**

- What is the relationship between gravity and the motions of the objects in the solar system?
- In what ways does the Sun influence the Earth?
- How do astronomers classify celestial objects?
- What is the history of space exploration within our planetary system?

**Objectives**

**Students will know (DCIs):**

- Although active geological 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.

- Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources to minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

**Students will be able to (SEPs):**

- Identify and describe the trajectories of orbiting bodies, including planets, moons, or human-made spacecraft; each of which depicts a revolving body's eccentricity using a computer model (Kepler's first law of planetary motion).
- The square of a revolving body's period of revolution is proportional to the cube of its distance to a gravitational center (Kepler's third law of planetary motion).
- Use Kepler's second law of planetary motion to predict the relationship between the distance between an orbiting body and its star, and the object's orbital velocity, and check the accuracy using a computer model.

# UNIT 3: STARS AND STELLAR EVOLUTION

## Summary and Rationale

In this unit of study, students explore the stellar life cycle. Stars go through a sequence of developmental stages—they are formed; evolve in size, mass, and brightness; and eventually burn out. Material from earlier stars that explode as supernovas is recycled to form younger stars and their planetary systems. Students explore how all elements beyond Helium were made by fusion in a star's core or in the high temperature and pressure of a supernova. The Sun's layers and features are discussed in addition to how the Sun devastates other planets with its magnetic fields and heat. In addition students investigate the galaxies made up of these stars, and categorize their characteristics.

## Recommended Pacing

14 days

## State Standards

**HS-ESS 1-1 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.**

| | |
|---|---|
| Clarification Statement | Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries. |
| Assessment Boundary | Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion. |

**HS-ESS 1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.**

| | |
|---|---|
| Clarification Statement | Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. |
| Assessment Boundary | Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed. |

**HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constrains for solutions that account for societal needs and wants.**

**HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**

## Instructional Focus

**Unit Enduring Understandings (Cross Cutting Concepts)**

- We are stardust. Earth was formed from debris left from exploding stars. All elements beyond Helium were made through fusion or supernova explosions.
- The Sun and other stars follow similar life cycles, leaving the galaxy enriched with heavy elements
- Finding galaxies in different shapes reveals the past, present, and future of the universe

**Unit Essential Questions**

• How is the process of energy production in the Sun explained?
• What role does the Sun play in our solar system?
• How does the mass of a star affect its life cycle?
• What are the stages in the evolution of a star?
• What are the properties used to classify stars?

**Objectives**

**Students will know (DCIs):**

- The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.
- The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements and their distances from Earth.
- 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 supernova stage and explode.
- Both physical models and computers can be used in various ways to aid in the process of studying stars and stellar evolution.

**Students will be able to (SEPs):**

- Identify and communicate the relationship between the life cycle of the stars, the production of elements, and conservation of the number of protons, plus neutrons in the stars.
- Describe that helium and a small amount of other light nuclei were formed from high energy collisions starting from protons and neutrons in the early universe before any stars existed.
- Describe that more massive elements, up to iron, are produced in the cores of stars by a chain of processes of nuclear fusion, which also releases energy.
- Describe that supernova explosions of massive stars are the mechanism by which elements more massive that iron are produced.
- Describe that there is a correlation between a star's mass and stage of development and the types of elements it can create during its lifetime.
- Describe that electromagnetic emission and absorption spectra are used to determine a star's composition, motion and distance to earth.