# Virginia Science Content Guidelines: Astronomy

The goal of this course is to provide students with an introduction to the concepts of modern astronomy, the origin and history of the Universe, and the formation of the Earth and the solar system. The course gives a description of astronomical phenomena using the laws of physics. The course treats many standard topics including planets, stars, the Milky Way and other galaxies, black holes, and the origin of the universe. There should be descriptive and comparative studies as well as investigations. Teachers should work with local science organizations, including observatories and planetariums.

## Scientific Inquiry

A.1 The student will demonstrate an understanding of scientific skills and process by.

1. asking questions and defining problems

* ask questions that arise from careful observation of phenomena, examination of a model or theory, or unexpected results, and/or to seek additional information
* determine which questions can be investigated
* make hypotheses that specify what happens to a dependent variable when an independent variable is manipulated
* define design problems that involves the development of a process or system with interacting components and criteria and constraints

1. planning and carrying out investigations

* individually and collaboratively plan and conduct observational and experimental investigations
* plan and conduct investigations or test design solutions in a safe manner
  + select and use appropriate tools and technology, including telescopes, to collect, record, analyze, and evaluate data

1. interpreting, analyzing, and evaluating data

* record and present data in an organized format that communicates relationships and quantities in appropriate mathematical or algebraic forms
* use data in building and revising models, supporting explanation for phenomena, or testing solutions to problems
* analyze data using tools, technologies, and/or models (e.g., computational, mathematical, statistical) in order to make valid and reliable scientific claims or determine an optimal design solution
* analyze data graphically and use graphs to make predictions;
* consider limitations of data analysis when analyzing and interpreting data
* evaluate the impact of new data on a working explanation and/or model of a proposed process or system
* analyze data to optimize a design

1. constructing and critiquing conclusions and explanations

* make quantitative and/or qualitative claims based on data
* construct and revise explanations based on valid and reliable evidence obtained from a variety of sources
* apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena or design solutions
* compare and evaluate competing arguments in light of currently accepted explanations and new scientific evidence
* construct arguments or counterarguments based on data and evidence
* differentiate between scientific hypothesis, theory, and law

1. developing and using models
   * evaluate the merits and limitations of models, including cosmology models
   * identify and communicate components of a system orally, graphically, textually, and mathematically
   * develop and/or use models (including mathematical and computational) and simulations to visualize, explain, and predict phenomena and to interpret data sets
2. obtaining, evaluating, and communicating information

* compare, integrate, and evaluate sources of information presented in different media or formats to address a scientific question or solve a problem.
* gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and credibility of each source
* communicate scientific and/or technical information about phenomena and/or a design process in multiple formats

A.2 The student will investigate and understand that astronomy has had an important role from antiquity to the modern era. Key concepts include

* constellations are historical groupings of stars that helped ancient astronomers order the night sky and navigate the oceans;
* ancient astronomers understood the world using simple astronomical tools (including the astrolabe, charts, and trigonometric tools) and developed models of the Universe;
* Renaissance era astronomers reexamined ancient models and developed new understandings of how the Universe is ordered;
* engineering in the modern space age has developed new space exploration technology which has led to large advances in the understanding of astronomy and planetary sciences; and
* technologies developed for space exploration are used in everyday life.

## Physical Laws and Processes

A.3 The student will investigate and understand that gravity governs the universe. Key concepts include

* gravity keeps planets in orbits around the sun and governs the motion of the solar system;
* gravity is a universal force between two objects (Newtonian gravity); and
* Kepler’s Laws of Planetary Motion describe planetary motion around the sun.

A.4 The student will investigate and understand that electromagnetic radiation is fundamental in understanding our universe. Key concepts include

* light has specific properties;
* spectral signatures are used for identification;
* wave energy has general behaviors within the electromagnetic spectrum; and
* properties of electromagnetic radiation include wave shape and speed, reflection, refraction, diffraction, interference, polarization, Doppler effect, blackbody curves, and wave/particle duality.

A.5 The student will investigate and understand that challenges face astronomers in studying electromagnetic radiation to determine composition, motions, and other physical attributes of astronomical objects. Key concepts include

* astronomers use tools to study electromagnetic radiation
* the properties of light and the vast distances in the cosmos are challenges in studying the universe; and
* there are advantages and limitations to different types of telescopes used by astronomers for examining different frequencies of electromagnetic radiation.

A.6 The student will investigate and understand that energy transfers and energy transformations are significant in understanding the universe. Key concepts include

* the structure of the atom
* energy and matter are conserved;
* nuclear fusion reactions and mass-energy equivalence relate to the life cycle of stars;
* the energy produced by fusion relates to the luminosity of stars;
* there are energy relationships between the mass, power output, and life span of stars; and
* energy transfers and transformations are associated with the motion and interactions of celestial bodies (e.g. orbits, binary pulsars, meteors, black holes, and galaxy mergers).

## The Structure and Evolution of the Universe

A.7 The student will investigate and understand that the universe has evolved. Key concepts include

* Big Bang Theory is supported by evidence; and
* Hubble’s Law, mass-energy density of the universe, and deuterium abundance support an open universe.

A.8 The student will investigate and understand that star evolve. Key concepts include

* the life cycle of a star, gravity and mass are important in understanding the brightness, life span, and end-stages of stars;
* astronomers use specific methods to find physical properties of stars including surface temperature, luminosity, chemical composition, size, mass, interstellar medium, motion, and distance; and
* the stellar evolution of individual stars and the location of each on the Hertzsprung-Russell diagram, including protostars, main sequence stars, giants and supergiants, nova and supernova stars, variable stars, white dwarfs, neutron stars/pulsars, and black holes;
* extrasolar planetary systems have been discovered and have comparative qualities to our solar system.

A.9 The student will investigate and understanding that galaxies have different features Key concepts include

* our solar system is part of the Milky Way Galaxy; which has identifiable characteristics , including size, shape, rotation, and stellar distribution;
* the Hubble Classification System of Galaxies includes elliptical galaxies, spiral galaxies, barred-spiral galaxies, and irregular galaxies; and
* some galaxies do not conform to the original Hubble Classification System, including radio galaxies, Seyfert Galaxies, and quasars.

A.10 The student will investigate and understand that the physical characteristics of our sun can serve as a model of solar activities. Key concepts include

* a typical star such as our Sun has identifiable layers and internal mechanisms;
* there are surface features of a typical star;
* space has weather and the that weather has an effect on Earth; and
* there are research methods to analyze a typical star.

A.11 The student will investigate and understand that the solar system has structure and has evolved. Key concepts include

* natural forces and the conservation of angular momentum apply to the objects in our Universe, including the formation of planets and satellites and the retention of an atmosphere;
* the formation of the solar system is explained through, solar nebular theory, condensation theory, core accretion theory, and gravitational instability theory;
* Earth’s physical properties, including density, composition, and position in space, can be compared to other planets’ physical properties;
* terrestrial planets and the Jovian planets have general similarities and difference as well as unique features; and
* minor members, including asteroids, comets, and meteors, share our solar system

## Patterns in the Sky

A.12 The student will investigate and understand that there are sun-Earth-moon relationships. Key concepts include

* the Earth has a specific the orbital velocity, eccentricity tilt, rotation, and revolution;
* the relationship between the sun and the earth causes the seasons
* the moon has lunar phases, geological features of the moon and how they form, cause and effect of tides on Earth, and the formation of the moonumbra and penumbra, total eclipses, partial eclipses; and
* annular eclipses.

A.13 The student will investigate and understand that the moon has yearly and daily patterns and moon phases. Key concepts include

* Examining astronomical cycles in nature and apply them to the daily, monthly, and yearly cycles of Earth.