

Astronomy AB Course Description

Astronomy AB (Annual Course – Grades 11 & 12 - Prerequisites: Algebra 1, Geometry and Physics (Physics may be taken concurrently.)

36-17-11 Astronomy A

36-17-12 Astronomy B

Course Description

Astronomy AB is an advanced science course. The purpose of Astronomy AB is to present a representative sample of the known facts, evolving ideas and frontier discoveries in contemporary astronomy. The course will highlight both the scientific principles and underlying work done in astronomy and the process used in discovery. These concepts will reinforce student's understanding of the Scientific Method, how the universe works and connections among the various fields of science.

The basic units of study are:

Unit 1 Astronomy and the Universe	Astronomy of the universe and how the concepts of motion, time and distance are applied in the larger scheme of the universe. How we obtain information from the cosmos; Radiation, spectroscopy and telescopes
Unit 2 Comparative Planetology	Our Solar system, planetary characteristics and formation and the moon.
Unit 3 Stars And Stellar Evolution	The sun, its properties and the activities of the sun. Understanding how stars progress through their life span. Main Sequence Stars, Neutron Stars and Black Holes.
Unit 4 Large Scale Structure of the Cosmos	Cosmology, galaxies, the Big Bang Theory and dark matter.

INSTRUCTIONAL UNITS

Unit1: Astronomy and the Universe

Charting The Heavens: The Foundations of Astronomy

- Our Place in Space
- Scientific Theory and the Scientific Method
- The "Obvious" View (Angular Measure and Celestial Coordinates)

- Earth's Orbital Motion
- Astronomical Timekeeping
- The Motion of the Moon
- The Measurement of Distance

The development of the Study of Astronomy: The Birth of Modern Science

- Ancient Astronomy
- The Geocentric Universe
- The Heliocentric Model of the Solar System
- The Birth of Modern Astronomy
- The Laws of Planetary Motion
- The Dimensions of the Solar System
- Newton's Laws
- Newtonian Mechanics

Radiation: Information from the Cosmos

- Information from the Skies
- Waves and how they are affected by the medium of travel
- The Electromagnetic Spectrum
- Thermal Radiation
- The Doppler Effect

Spectroscopy: The Inner Workings of Atoms

- Spectral Lines
- Atoms and Radiation
- The Formation of Spectral Lines
- Molecules
- Spectral-Line Analysis

Telescopes: The Tools of Astronomy

- Optical Telescopes
- Telescope Size
- Images and Detectors
- High-Resolution Astronomy
- Radio Astronomy
- Interferometry
- Space-Based Astronomy
- Full-Spectrum Coverage

Unit 2: Comparative Planetology

The Solar System: An Introduction to Comparative Planetology

- An Inventory of the Solar System
- Measuring the Planets
- The Overall Layout of the Solar System
- Terrestrial and Jovian Planets
- Interplanetary Matter
- Spacecraft Exploration of the Solar System
- How Did the Solar System Form?

Earth: Our Home in Space

- Overall Structure of Planet Earth
- Earth's Atmosphere
- Earth's Interior
- Surface Activity
- Earth's Magnetosphere
- The Tides

The Moon and Mercury: Scorched and Battered Worlds

- Orbital Properties
- Physical Properties
- Surface Features on the Moon and Mercury
- Rotation Rates
- Lunar Cratering and Surface Composition
- The Surface of Mercury
- Interiors
- The Origin of the Moon
- Evolutionary History of the Moon and Mercury

Venus: Earth's Sister Planet

- Orbital Properties
- Physical Properties
- Long-Distance Observations of Venus
- The Surface of Venus
- The Atmosphere of Venus
- Venus's Magnetic Field and Internal Structure

Mars: A Near Miss for Life?

- Orbital Properties
- Physical Properties
- Long-Distance Observations of Mars
- The Martian Surface
- Water on Mars
- The Martian Atmosphere
- Martian Internal Structure

- The Moons of Mars

Jupiter: Giant of the Solar System

- Orbital and Physical Properties
- The Atmosphere of Jupiter
- Internal Structure
- Jupiter's Magnetosphere
- The Moons of Jupiter
- Jupiter's Ring

Saturn: Spectacular Rings and Mysterious Moons

- Orbital and Physical Properties
- Saturn's Atmosphere
- Saturn's Interior and Magnetosphere
- Saturn's Spectacular Ring System
- The Moons of Saturn

Uranus, Neptune, and Pluto: The Outer Worlds of the Solar System

- The Discoveries of Uranus and Neptune
- Orbital and Physical Properties
- The Atmospheres of Uranus and Neptune
- Magnetospheres and Internal Structure
- The Moon Systems of Uranus and Neptune
- The Rings of the Outermost Jovian Planets

Solar System Debris: Keys to Our Origin

- Asteroids
- Comets
- Beyond Neptune
- Meteoroids

The Formation of Planetary Systems: The Solar System and Beyond

- Modeling Planet Formation
- Formation of the Solar System
- Terrestrial and Jovian Planets
- Solar System Regularities and Irregularities
- Planets Beyond the Solar System
- Is Our Solar System Unusual?

Unit 3: Stars And Stellar Evolution

The Sun: Our Parent Star

- Physical Properties of the Sun

- The Solar Interior
- The Solar Atmosphere
- Solar Magnetism
- The Active Sun
- The Heart of the Sun
- Observations of Solar Neutrinos

Measuring the Stars: Giants, Dwarfs, and the Main Sequence

- The Solar Neighborhood
- Luminosity and Apparent Brightness
- Stellar Temperatures
- Stellar Sizes
- The Hertzsprung-Russell Diagram
- Extending the Cosmic Distance Scale
- Stellar Masses
- Mass and Other Stellar Properties

The Interstellar Medium: Gas and Dust Among the Stars

- Interstellar Matter
- Emission Nebulae
- Dark Dust Clouds
- 21-Centimeter Radiation
- Interstellar Molecules

Star Formation: A Traumatic Birth

- Star-Forming Regions
- The Formation of Stars Like the Sun
- Stars of Other Masses
- Observations of Cloud Fragments and Protostars
- Shock Waves and Star Formation
- Star Clusters

Stellar Evolution: The Life and Death of a Star

- Leaving the Main Sequence
- Evolution of a Sun-like Star
- The Death of a Low-Mass Star
- Evolution of Stars More Massive than the Sun
- Observing Stellar Evolution in Star Clusters
- Stellar Evolution in Binary Systems

Stellar Explosions: Novae, Supernovae, and the Formation of the Elements

- Life after Death for White Dwarfs
- The End of a High-Mass Star

- Supernovae
- The Formation of the Elements
- The Cycle of Stellar Evolution

Neutron Stars and Black Holes: Strange States of Matter

- Neutron Stars
- Pulsars
- Neutron-Star Binaries
- Gamma-Ray Bursts
- Black Holes
- Einstein's Theories of Relativity
- Space Travel Near Black Holes
- Observational Evidence for Black Holes

Unit 4: Galaxies And Cosmology

The Milky Way Galaxy: A Spiral in Space

- Our Parent Galaxy
- Measuring the Milky Way
- Galactic Structure
- The Formation of the Milky Way
- Galactic Spiral Arms
- The Mass of the Milky Way Galaxy
- The Galactic Center

Galaxies: Building Blocks of the Universe

- Hubble's Galaxy Classification
- The Distribution of Galaxies in Space
- Hubble's Law
- Active Galactic Nuclei
- The Central Engine of an Active Galaxy

Galaxies and Dark Matter: The Large-Scale Structure of the Cosmos

- Dark Matter in the Universe
- Galaxy Collisions
- Galaxy Formation and Evolution
- Black Holes in Galaxies
- The Universe on Large Scales

Cosmology: The Big Bang and the Fate of the Universe

- The Universe on the Largest Scales
- The Expanding Universe

- The Fate of the Cosmos
- The Geometry of Space
- Will the Universe Expand Forever?
- Dark Energy and Cosmology
- The Cosmic Microwave Background

The Early Universe: Toward the Beginning of Time

- Back to the Big Bang
- The Evolution of the Universe
- The Formation of Nuclei and Atoms
- The Inflationary Universe
- The Formation of Structure in the Universe
- Cosmic Structure and the Microwave Background

Life In The Universe: Are We Alone?

- Cosmic Evolution
- Life in the Solar System
- Intelligent Life in the Galaxy
- The Search for Extraterrestrial Intelligence

LABORATORY ACTIVITIES LIST

Following is a list of the laboratory activities for Astronomy AB grouped by instructional unit.

Unit1: Astronomy and the Universe

Charting the Heavens

- Significant Figures and Scientific Notation: Review of astronomy-associated mathematics.
- Astronomy in the Marketplace: Compile list of astronomy-associated commercial names.
- Star Chart : Construct an individual star chart
- Constellations: Observe and identify constellations using constructed star chart (Outdoor experiment).
- Winter Solstice: Measure the angle of the sun for 4 months (Outdoor experiment).
- Time Zone Model: Construct a 3D model showing earth time zones.
- Sun Clock: Construct and use a device to tell time by the sun. (Outdoor experiment).
- Moon Phases: Observe and draw the moon for 2 weeks (Outdoor experiment)
- Eclipses and Phases of the Moon: Model with light source and balls.
- Distance to the Moon: .Estimate using proportional mathematics (Outdoor experiment).
- Diameter of the Moon: Estimate using proportional mathematics (Outdoor experiment)
- Parallax: Illustrate parallax method for finding astronomical distances.

The Copernican Revolution

- Colors of the Sky: Illustrate using a chemical reaction.

- Kepler's First Law: Draw ellipses,
- Kepler's Third Law: Illustrate with ball and lengths of string.
- Newton's First Law: Various inertia experiments from classical physics.
- Newton's Second Law: Various motion experiments showing $F = ma$.
- Planetary Soda Cans: Compare the weights of soda cans on the various planets.

Radiation

- Waves: Illustrate Types of waves with *Slinkies*.
- Light Refraction: Illustrate bending of light through water and glass lenses.

Spectroscopy

- Electromagnetic Spectrum: Identify emission spectra from gas tubes with spectroscope.
- Doppler Effect: Construct buzzing device and use to show Doppler Effect

Telescopes

- Making a Refracting Telescope Model: Use optics lenses to calculate focal lengths.
- Schlieren Patterns: Illustrate atmospheric disturbance of starlight.
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Unit 2: Comparative Planetology

The Solar System

- Solar System Distances: Use scale model to show comparative distances (Outdoor experiment).
- Planets: Use mathematical proportions to compare planet sizes.

Earth

- Longitude & Latitude: Construct and use a 3D model to show locations of points on the earth.
- Continental Drift: Illustrate some evidence for the theory.

The Moon and Mercury

- Lava Layering: Construct a clay model showing lava flow and resulting layers.
- Impact Craters: Use balls dropped into powder to show crater formation.
- Moon Surface: Make a scale model of part of the moon surface. Put parts together for class model.

Venus

- Greenhouse Effect: Construct house with plastic "window" and measure temperature with thermal probe

Mars

- Isostasy: Illustrate balance between forces of gravity and buoyancy.

Jupiter

- Red Spot Speed of Clouds: Use time-spaced overlays to compare cloud locations.
- Red Spot Rotation Period: Use overlay data to calculate rotation period.

Saturn

- Saturn's Rings: Construct a 3D model.

Solar System Debris

- Asteroid: Use clay to sculpt a 3D model.
- Comet: Create a flip book to show the varying speed of a comet.
- Recipe for a Comet: Combine ingredients to show make-up of a comet.

The Formation of Planetary Systems

- Transit Light Curves: Use light differences to locate extra solar planets.

Unit 3: Stars And Stellar Evolution

The Sun

- Finding Sun's Diameter: Use proportional mathematics to calculate.
- Solar Constant: Calculate using sun-heated water and associated mathematics (Outdoor experiment).
- Projecting the Sun: Indirect observation of the sun (Outdoor experiment).

The Stars

- Our Small Speck: Use grains of salt to illustrate the number of stars.

Star Formation

- No Bake Gravity: Make cookies to show the formation of stars.

Unit 4: Galaxies And Cosmology

The Milky Way Galaxy

- Your place in the galaxy: Use Red Shift data from NASA
- Graphing Cepheid Variable Stars: Use star data from NASA

Galaxies

- Classifying & Identifying Galaxies: Use pictures from Hubble telescope from NASA
- Estimating Distances in Space: Use proportional mathematics and NASA data.
- Graphing Hubble's Constant: Graphically show evidence for the Big Bang theory.

EARTH SCIENCES STANDARDS COVERED

(From the California State Standards)

Earth's Place in the Universe

1. Astronomy and planetary exploration reveal the solar system's structure, scale, and change over time. As a basis for understanding this concept:
 - a. Students know how the differences and similarities among the sun, the terrestrial planets, and the gas planets may have been established during the formation of the solar system.
 - b. Students know the evidence from Earth and moon rocks indicates that the solar system was formed from a nebular cloud of dust and gas approximately 4.6 billion years ago.
 - c. Students know the evidence from geological studies of Earth and other planets suggest that the early Earth was very different from Earth today.
 - d. Students know the evidence indicating that the planets are much closer to Earth than the stars are.
 - e. Students know the Sun is a typical star and is powered by nuclear reactions, primarily the fusion of hydrogen to form helium.
 - f. Students know the evidence for the dramatic effects that asteroid impacts have had in shaping the surface of planets and their moons and in mass extinctions of life on Earth.
 - g.* Students know the evidence for the existence of planets orbiting other stars.
2. Earth-based and space-based astronomy reveal the structure, scale, and changes in stars, galaxies, and the universe over time. As a basis for understanding this concept:
 - a. Students know the solar system is located in an outer edge of the disc-shaped Milky Way galaxy, which spans 100,000 light years.
 - b. Students know galaxies are made of billions of stars and comprise most of the visible mass of the universe.
 - c. Students know the evidence indicating that all elements with an atomic number greater than that of lithium have been formed by nuclear fusion in stars.
 - d. Students know that stars differ in their life cycles and that visual, radio, and X-ray

telescopes may be used to collect data that reveal those differences.

- e.* Students know accelerators boost subatomic particles to energy levels that simulate conditions in the stars and in the early history of the universe before stars formed.
- f.* Students know the evidence indicating that the color, brightness, and evolution of a star are determined by a balance between gravitational collapse and nuclear fusion.
- g.* Students know how the red-shift from distant galaxies and the cosmic background radiation provide evidence for the big bang model that suggests that the universe has been expanding for 10 to 20 billion years.

Energy in the Earth System

- 4. Energy enters the Earth system primarily as solar radiation and eventually escapes as heat. As a basis for understanding this concept:
 - a. Students know the relative amount of incoming solar energy compared with Earth's internal energy and the energy used by society.
 - b. Students know the fate of incoming solar radiation in terms of reflection, absorption, and photosynthesis.
 - c. Students know the different atmospheric gases that absorb the Earth's thermal radiation and the mechanism and significance of the greenhouse effect.
 - d.* Students know the differing greenhouse conditions on Earth, Mars, and Venus; the origins of those conditions; and the climatic consequences of each.

Investigation and Experimentation

- 1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
 - a. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
 - b. Identify and communicate sources of unavoidable experimental error.
 - c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

- d. Formulate explanations by using logic and evidence.
- e. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.
- f. Distinguish between hypothesis and theory as scientific terms.
- g. Recognize the usefulness and limitations of models and theories as scientific representations of reality.
- h. Read and interpret topographic and geologic maps.
- i. Analyze the locations, sequences, or time intervals that are characteristic of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
- j. Recognize the issues of statistical variability and the need for controlled tests.
- k. Recognize the cumulative nature of scientific evidence.
- l. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.
- m. Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples of issues include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.
- n. Know that when an observation does not agree with an accepted scientific theory, the observation is sometimes mistaken or fraudulent (e.g., the Piltdown Man fossil or unidentified flying objects) and that the theory is sometimes wrong (e.g., the Ptolemaic model of the movement of the Sun, Moon, and planets).

PHYSICS STANDARDS REVIEWED

Motion and Forces

- 1. Newton's laws predict the motion of most objects. As a basis for understanding this concept:
 - a. Students know how to solve problems that involve constant speed and average speed.

- b. Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
- c. Students know how to apply the law $f=ma$ to solve one-dimensional motion problems that involve constant forces (Newton's second law).
- d. Students know that when one object exerts a force on a second object, the second object always exerts a force of equal magnitude and in the opposite direction (Newton's third law).
- e. Students know the relationship between the universal law of gravitation and the effect of gravity on an object at the surface of Earth.
- f. Students know applying a force to an object perpendicular to the direction of its motion causes the object to change direction but not speed (e.g., Earth's gravitational force causes a satellite in a circular orbit to change direction but not speed).
- h.* Students know Newton's laws are not exact but provide very good approximations unless an object is moving close to the speed of light or is small enough that quantum effects are important.
- I.* Students know how to solve two-dimensional trajectory problems.
- j.* Students know how to resolve two-dimensional vectors into their components and calculate the magnitude and direction of a vector from its components.

Conservation of Energy and Momentum

- 2. The laws of conservation of energy and momentum provide a way to predict and describe the movement of objects. As a basis for understanding this concept:
 - b. Students know how to calculate changes in gravitational potential energy near Earth by using the formula (change in potential energy) $=mgh$ (h is the change in the elevation).
 - f. Students know an unbalanced force on an object produces a change in its momentum.

Heat and Thermodynamics

- 3. Energy cannot be created or destroyed, although in many processes energy is transferred to the environment as heat. As a basis for understanding this concept:
 - c. Students know the internal energy of an object includes the energy of random

motion of the object's atoms and molecules, often referred to as thermal energy. The greater the temperature of the object, the greater the energy of motion of the atoms and molecules that make up the object.

- d. Students know that most processes tend to decrease the order of a system over time and that energy levels are eventually distributed uniformly.

Waves

- 4. Waves have characteristic properties that do not depend on the type of wave. As a basis for understanding this concept:
 - a. Students know waves carry energy from one place to another.
 - e. Students know radio waves, light, and X-rays are different wavelength bands in the spectrum of electromagnetic waves whose speed in a vacuum is approximately 186,000 miles/second.

CHEMISTRY STANDARDS REVIEWED

Atomic and Molecular Structure

- 1. The periodic table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure. As a basis for understanding this concept:
 - f. Students know how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.
 - j.* Students know that spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related $E=h\nu$.