Astronomy Curriculum
(3221)

Astronomy is an exciting elective for students that enjoy the more inclusive conceptual aspects of Physics without the intense emphasis on calculations. The Astronomy curriculum focuses on the big picture topics: the Fundamentals, the Celestial Sphere, the Evolution of the Cosmological Model, Remote Methods of Making Observations, Our Solar System, Our Sun and the Stars. Also included are the suggested but optional units: Dangers in Our Universe, the Search for Extraterrestrial Life and Space Travel. Integrated within the curriculum are many opportunities for inquiry activities. It is suggested that teachers utilize a final group research project that allows students to summarize course studies; setting the stage for life long learning about the cosmos.

Update Summer 2011

Astronomy: Fundamentals

Pacing guide

8% course instruction days (7 days)

Guiding Question

What tools, skills, and knowledge, are necessary for the student to be successful in Astronomy?

Course Level Expectations	Checks for Understanding
CLE 3221.Fund.1 Able to understand and utilize SI units and other astronomy-based units.	✓**3221. Fund.1** Students solve practice SI unit/astronomy based practice problems.
CLE 3221. Fund.2 Able to understand and utilize scientific notation and the concept of orders of magnitude.	✓**3221. Fund.2** Students compare sizes of stars and planets using scientific notation.
CLE 3221. Fund.3 Able to understand and utilize concepts in simple algebraic equations.	✓**3221. Fund.3** Students solve problems relating rate, amount, and time using algebraic equations.
CLE 3221. Fund.4 Able to understand and utilize "skinny triangles" and elementary geometry.	✓**3221. Fund.4** Students solve problems involving "skinny triangles" and elementary geometry to determine relative size, distance, and apparent angular size.
CLE 3221. Fund.5 Able to understand and utilize elementary geometry and circles to relate radius, diameter, circumference and arc length.	✓**3221. Fund.5** Students solve problems involving circles, their component parts, and relationships between their parts.
CLE 3221. Fund.6 Able to understand and utilize the concepts of latitude, longitude, equator, prime meridian, poles, altitude, azimuth, zenith, and nadir.	✓**3221. Fund.6** Students define latitude and longitude and solve problems that relate these geographical constructs.

Astronomy: Celestial Sphere

Pacing guide

12% course instruction days (10 days)

Guiding Question

How do astronomers navigate the night sky?

Course Level Expectations	Checks for Understanding
CLE 3221.Celes.1 Able to understand and utilize the celestial sphere model of the sky, including concepts of constellations, asterisms, celestial equator and poles, declination, right ascension. **CLE 3221. Celes.2** Able to understand the significance of the pole star, Polaris, and its connection with the apparent motion of the celestial sphere. **CLE 3221.Celes.3** Able to understand and utilize the various cycles and the apparent motion involving the stars, the Sun, and the Moon, including concepts of sidereal and solar day, sidereal and synodic month, sidereal and tropical year, the ecliptic, the equinoxes and solstices. **CLE 3221.Celes.4** Able to understand and utilize the yearly cycle of seasons and its connection to the obliquity of the Earth's axis... **CLE 3221.Celes.5** Able to understand and utilize the cause and effect of precession. **CLE 3221.Celes.6** Able to understand the phases of the Moon in terms of the observed cycle and its causes.	✓**3221. Celes.1** Students use simulation software such as Starry Night to discover the use of this tool and complete a workbook activity where these concepts are practiced. ✓**3221. Celes.2** Students describe, using a Celestial Sphere model or software, how the motion of the pole star is connected with the apparent motion of the celestial sphere. ✓**3221. Celes.3** Student should be able to describe, using a Celestial Sphere model or software to solve related problems. ✓**3221.Celes.4** Students describe, the cycle of seasons, using a Celestial Sphere model or software and solve related problems. ✓**3221.Celes.5** Students solve problems involving circles, their component parts, and relationships between their parts. ✓**3221.Celes.6** Students describe the phases of the moon; using a model, drawings or software. ✓**3221.Celes.7** Students describe the types of eclipses and their associated cycles; using a model, drawings or software.

CLE 3221.Celes.7 Able to understand the various types of eclipses and the associated cycles.	

Astronomy: The Evolution of the Cosmological Model

Pacing guide

10% course instruction days (8 days)

Guiding Questions

What is the current thinking on the origin of the Universe? How have Astronomers developed theories for the origin and subsequent model for the Universe?

Course Level Expectations	Checks for Understanding
CLE 3221.Cosmo.1 Able to understand the basics of the "naked-eye" observations made by early astronomers, including concepts of: prograde and retrograde motion, elongation, conjunction and opposition, variation in apparent brightness, etc. **CLE 3221. Cosmo.2** Understand the ancient geocentric models of the universe and planetary motion including the works of Aristotle and Ptolemy and the concepts of deferents and epicycles. **CLE 3221. Cosmo.3** Understand heliocentric model of the universe and planetary motion proposed by Copernicus and proven by Galileo. **CLE 3221. Cosmo.4** Understand Kepler's three laws of planetary motion and Tycho Brahe's contribution. **CLE 3221. Cosmo.5** Understand Newton's laws of motion.	✓**3221. Cosmo.1** Students describe the apparent motion and properties to include concepts of: prograde and retrograde motion, elongation, conjunction and opposition, variation in apparent brightness, etc... ✓**3221. Cosmo.2** Students explain and illustrate aspects of ancient geocentric models of the universe and planetary motion. ✓**3221. Cosmo.3** Students explain and illustrate the heliocentric model of the Universe. ✓**3221. Cosmo.4** Students explain, illustrate, and apply Kepler's three laws of planetary motion. ✓**3221. Cosmo.5** Students describe and illustrate in qualitative terms Newton's laws and how Newton's laws superseded Kepler's.

CLE 3221. Cosmo.6 Understand the role gravity plays in the construction, composition and shape of planets. **CLE 3221. Cosmo.7** Understand the development of the Big Bang theory of the formation of the Universe and how the scientific method was utilized to form/ support this theory.	✓**3221. Cosmo.6** Students explain and illustrate the role of gravity in construction, composition and shape of planets. ✓**3221. Cosmo.7** Students write a cross-curriculum essay that describes the process how the scientific method was used to develop the current cosmological model and the Big Bang theory of the formation of the Universe.

Astronomy: Remote Methods of Observation

Pacing guide

12% course instruction days (10 days)

Guiding Questions

What methods do Astronomer's use to make remote observations, what is the science behind these methods, and how do we choose a method given a set of conditions?

Course Level Expectations	Checks for Understanding
CLE 3221.Obs.1 Understand the types and basic concepts of Electromagnetic radiation. **CLE 3221. Obs.2** Understand the characteristics of the visual spectrum of Electromagnetic. **CLE 3221. Obs.3** Understand the Doppler Effect and how astronomers use the Doppler Effect. **CLE 3221. Obs.4** Understand the basic concepts of blackbody radiation. **CLE 3221. Obs.5** Understand the technical aspects of Optical telescopes and their limitations.	✓**3221. Obs.1** Students describe and illustrate the various types of Electromagnetic Radiation. ✓**3221. Obs.2** Students illustrate, apply and solve problems relating to Electromagnetic Radiation: frequency, wavelength, and speed as they relate to source and medium. ✓**3221. Obs.2** Students define all aspects of visible light: by frequency and wavelength. ✓**3221. Obs.4** Students explain, illustrate, and apply the concept of the Doppler Effect. Explain how red shift and blue shift can be used by astronomers.

CLE 3221. Obs.6 Understand spectroscopy and its uses within astronomy. **CLE 3221. Obs.7** Understand how remote observation is affected by atmosphere and position.	✓**3221. Obs.3** Students explain and apply the basic concepts of blackbody radiation and solve related problems. ✓**3221. Obs.4** Students construct a refractor telescope from a kit. Students compare and contrast reflector and refractor telescopes in terms of resolution, light gathering and magnification. ✓**3221. Obs.5** Students can solve simple thin lens optics mathematical problems. ✓**3221. Obs.5** Students use an inexpensive spectroscope to identify the elements within light sources. ✓**3221. Obs.6** Students pick alternative best methods to remotely observe stars and planets given a set of limiting atmospheric conditions.

Astronomy: Our Solar System

Pacing guide

13% course instruction days (11 days)

Guiding Questions

What are the objects in our Solar System, what is their composition and what are their characteristics?

Course Level Expectations	Checks for Understanding
CLE 3221.Sys.1 Understand the arrangement and planets in our Solar System. **CLE 3221.Sys.2** Understand the concepts relating to the formation of bodies within the solar system.	✓**3221.Sys.1** Students identify the eight planets and list them in order of distance from the sun. ✓**3221.Sys.2** Students describe following concepts and relate them to the formation of bodies within the solar system: protoplanets, protosun, condensation nuclei, accretion, planetesimals, and fragmentation.

CLE 3221.Sys.3 Understand the differences between planets in the solar system. **CLE 3221.Sys.4** Understand the properties of the orbits of planets within the solar system. **CLE 3221.Sys.5** Understand the number and properties of the moons within the solar system. **CLE 3221.Sys.6** Understand the asteroid belt, Kuiper belt, and Oort cloud. **CLE 3221.Sys.7** Understand the general makeup and characteristics of asteroids and comets. **CLE 3221.Sys.8** Understand the characteristics of a planet that control planet temperature and what this means in terms of life on a planet. **CLE 3221.Sys.9** Understand the role of planetary magnetic fields within the solar system.	✓**3221.Sys.3** Students compare and contrast the characteristics of each planet type, identify each planet by their type, and predict characteristics of a given planet based on type. ✓**3221.Sys.4** Students describe the general characteristics of planets orbits with respect to: eccentricity, orbital inclination, axial and axial tilt. ✓**3221.Sys.5** Students identify the number of moons of each planet in the solar system. Identify and describe the major moon(s) of Earth, Mars, Jupiter and Saturn. ✓**3221.Sys.6** Students identify the location and makeup of the asteroid belt, Kuiper belt and Oort cloud. ✓**3221.Sys.7** Students simulate asteroid impact craters by using marbles impacting on sand and compare them to lunar craters. Describe and illustrate impact crater cross sections. Describe the structural makeup of asteroids and comets. ✓**3221.Sys.8** Students describe how planet albedo, greenhouse effect, and distance from the sun as it relates to the habitable zone of the solar system. ✓**3221.Sys.9** Students describe and define the role of planetary magnetic fields. Relate these fields to the protection of life on Earth.

Astronomy: Our Sun

Pacing guide

7% course instruction days (6 days)

Guiding Question

What is our Sun made of, how is it constructed, how does it work and what are its dangers?

Course Level Expectations	Checks for Understanding
CLE 3221.Sun.1 Understand the structure of the Sun. **CLE 3221.Sun.2** Understand the Sun's magnetic field and the effect it has on the activity, appearance and cycle of the Sun. **CLE 3221.Sun.3** Understand the Sun's fusion process. **CLE 3221.Sun.4** Understand the active regions on the Sun and their impact on the Earth: prominences, flares, spicules, and coronal mass ejections.	✓**3221.Sun.1** Students describe the overall structure of the Sun in terms of its core, radiation zone, convection zone, photosphere, chromosphere, transition zone, corona, and solar wind, and describe the basic properties and composition of each part listed. ✓**3221.Sun.2** Students observe and describe sunspots as seen on the surface of the sun using a solar telescope. Students explain the difference in magnetic field between solar minimum and solar maximum. ✓**3221.Sun.3** Students explain the fusion process by which the Sun produces energy. Relate this to: the law of conservation of energy and the strong nuclear force. ✓**3221.Sun.4** Students describe and explain the Effects of the active regions of the Sun and their effect on the Earth, including: prominences, and flares, spicules, and coronal mass ejections.

Astronomy: The Stars

Pacing guide

12% course instruction days (10 days)

Guiding Questions

How are stars classified and how do we determine their properties?

Course Level Expectations	Checks for Understanding
CLE 3221.Star.1 Understand how we measure the distance to a star. **CLE 3221.Star.2** Understand the method of spectroscopic parallax **CLE 3221.Star.3** Understand the methods used in determining a star's size, mass and type. **CLE 3221.Star.4** Understand the methods of determining the motion and velocity of a star. **CLE 3221.Star.5** Understand the concepts that help us differentiate between stars. **CLE 3221.Star.6** Understand the different types of binary star systems and how they are detected.	✓**3221.Star.1** Students define and apply stellar parallax and the unit of the parsec and relate to skinny triangles and other units such as meters and light years. ✓**3221.Star.2** Students describe and apply the method of spectroscopic parallax and explain the importance of luminosity class to this method. ✓**3221.Star.3** Students perform the exercise "Jewel box Universe" and create an H-R diagram to classify and understand different types of stars such as main sequence stars, red giants, blue giants, supergiants, red dwarfs, and white dwarfs. ✓**3221.Star.4** Students define and describe proper motion and methods by which the velocity of a star through space may be determined by including both radial and transverse velocity. ✓**3221.Star.5** Students define, contrast, and apply the concepts: absolute magnitude, intrinsic brightness, luminosity, apparent magnitude, apparent brightness, energy flux. ✓**3221.Star.6** Students describe and explain methods for determining a star's mass and relate to the different types of binary-star systems: visual binary, spectroscopic binary, and eclipsing binary.

*Astronomy: Dangers

Pacing guide

8% course instruction days (6.5 days)

Guiding Questions

What are the cosmic dangers in the Universe and how can we avoid them?

Course Level Expectations	Checks for Understanding
CLE 3221.Danger.1 Understand all the properties and aspects of a Black Hole. **CLE 3221.Danger.2** Explore the probability and ramifications of an asteroid impact with the Earth... **CLE 3221.Danger.3** Explore the causes and methods of protection from natural Cosmic Radiation.	✓**3221.Danger.1** Students describe and illustrate the properties of a Black Hole, including probable locations and relativistic space-time effects. ✓**3221.Danger.2** Students define and apply the Torino impact hazard scale to assess the potential dangers of asteroids and comets to Earth. ✓**3221.Danger.3** Students explain how the Earth's population could protect itself from an asteroid impact. ✓**3221.Danger.3** Students describe and illustrate the properties and causes of natural cosmic radiation and means of detection. ✓**3221.Danger.4** Students explain the rolls of Earth's atmosphere and magnetosphere in shielding humans from cosmic radiation and the challenges of shielding humans that travel through space beyond Earth.

*** An Optional Topic**

*Astronomy: The Search for Extraterrestrial Life

Pacing guide

8% course instruction days (6.5 days)

Guiding Questions

What is the probability of finding live in the Universe, how do we look for it and what should we expect?

Course Level Expectations	Checks for Understanding
CLE 3221.Life.1 What is the probability of finding life in the Universe? **CLE 3221. Life.2** Understand how we narrow our search to "likely" places to find living creatures. **CLE 3221. Life.3** Understand the extremes of life on Earth and apply this knowledge to form expectations regarding alien life. **CLE 3221. Life.3** Understand the likely process of "Terraforming" of a planet for human life.	✓**3221.Life.1** Students **e**xplain and illustrate the concept of a habitable zone and how this guides the search for Earth type planets. ✓**3221.Life.1** Students use provided data to pick a main sequence star of the proper age that would be a good host for life based on development of a habitable zone. ✓**3221.Life.1** Students state and apply the Drake equation and solve related problems. ✓**3221.Life.1** Students describe and explain the various methods used to detect exoplanets. ✓**3221.Life.1** Students give an overview of the characteristics of exoplanets found thus far and explain how there is likely a bias due to limitations of search methods. ✓**3221.Life.1** Students explain how life can produce a chemical signature that may be detected from great distances. ✓**3221.Life.1** Students describe and explain how the study of extremophiles living in harsh environments on Earth relates to the search for extraterrestrial life.

	✓**3221.Life.1** Students describe the process of Terraforming.
*** An Optional Topic**	

Astronomy: Space Travel

Pacing guide

12% course instruction days (10 days)

Guiding Questions

Why do we explore space, how do we explore space and what is the current status of space travel?

Course Level Expectations	Checks for Understanding
CLE 3221.Travel.1 Understand the benefits that can be derived from space travel **CLE 3221. Travel.2** Understand the different methods of exploring space. **CLE 3221. Travel.3** Understand current space missions and how these are developed.	✓**3221. Travel.1** Students discuss how international cooperation has helped the space program. ✓**3221. Travel.2** Students list information that can be obtained though a permanent space presence. ✓**3221. Travel.3** Students compare and contrast the various forms of propulsion and power for spacecraft: chemical fuel, solid fuel, nuclear, solar wind, ion propulsion, and others. ✓**3221. Travel.4** Students describe and explain the requirements of placing a satellite in orbit about a planet and describe the various types of orbits. ✓**3221. Travel.5** Students compare and contrast various types of robotic missions: rovers, satellites, flybys, sample return, etc.

	✓**3221. Travel.6** Students explain the development and implementation of manned missions to other planets and the unique challenges and dangers of such. ✓**3221. Travel 7** Students explain the physics of faster than light travel based on Einstein's theories. ✓**3221. Travel.1** Students compare and contrast robotic missions with manned missions and debate the merits of each with reference to actual historical missions such as Voyager, Pathfinder, Apollo, International Space Station, etc. ✓**3221. Travel.1** Student teams develop a simulated mission to another planet: from planet discovery, mission time line, propulsion, preparations for the health of astronauts, and other important preparations.
*** An Optional Topic**	

Resources

General Sites

- Indiana University held a workshop in the summer of 2006 on Astrobiology. The PowerPoint presentations and tools developed as a result of this workshop are available on-line for download.
  http://www.astro.indiana.edu/astrobio.shtml
- The UniverseForum is a web site produced for NASA by the Harvard Smithsonian Center for Astrophysics. The resources for teachers are excellent:
  http://www.cfa.harvard.edu/seuforum/learningresources.htm
  •The Open Directory Project: the largest, most comprehensive human-edited directory of the Web. It is constructed and maintained by a vast, global community of volunteer editors. Astronomy lesson plans of all types are indexed here.
  http://www.dmoz.org/Science/Astronomy/
- PBS and NOVA: NOVA is the highest rated science series on public television and offer many of these valuable programs for on-line viewing. These award winning broadcasts cover multiple topics. A few Physics/Astronomy favorites are: "The Elegant Universe," "Hunting the Hidden Dimension," and "Dark Matter."
  http://www.pbs.org/wgbh/nova/programs/
- NASA: has significant resources for educators. Their activities and lessons are for all age groups.
  http://teacherlink.ed.usu.edu/tlnasa/units/index.html

Reference Material

- The Astronomy Society of the Pacific has an excellent two volume set of amazing hands-on Astronomy activites available for under $60: "The Universe at Your Fingertips" and "More Universe at Your Fingertips" (stock number BS917).

Animations

- Indiana University has many simulations that are free downloads.
  http://www.astro.indiana.edu/animations/
  The University of British Columbia Astronomy and Astrophysics Department has a group of very interesting simulations posted by Rob Scharein.
  http://www.astro.ubc.ca/~scharein/a311/Sim.html
- Starry Night Software produces some of the best astronomy simulation software.
  http://www.starrynightstore.com/
- PhET: Interactive Simulations, University of Colorado, Boulder is one excellent source for fun simulations that promote student practice and interest in concepts. Simulations for the Solar System and optics are well worth class time.
  http://phet.colorado.edu/index.php
- Flash Animations for Physics: David M. Harrison, Dept. of Physics, Univ. of Toronto has developed an excellent page of animations designed to illustrate physics concepts. http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/#chaos