Glendale Unified School District

Senior High

December 11, 2012

Department:	Science
Course Title:	Physics-Based Astronomy 1-2
Course Number	7103D and 7104D
Grade Level:	11-12
Semester Credits:	10 (2 semesters)
Recommended Prerequisite:	Biology, Chemistry, Algebra I and Geometry
Recommended Textbook:	Astronomy Today, Seventh Edition, Chaisson & McMillan, Pearson Prentice Hall 2011

Course Description: Physics-Based Astronomy is an advanced upper division inquiry based lab science course of study on how we use physics to quantitatively observe, study, and analyze the functioning of the universe, and how the laws of physics are used to explain how the universe has evolved. Emphasis is placed on the use of the scientific method in student-oriented problem solving during extensive laboratory work, and with a strong reliance on current scientific literature and Internet resources.

Topics in forces, gravitation, kinematics, energy, electro-magnetism, thermodynamics, radiation, nuclear reactions, and relativity allow for an in-depth study of orbital motions, planetary characteristics, solar astrophysics, spectral analysis, stellar dynamics, galactic classifications, and cosmology, among others. At all stages, students are expected to use physics to mathematically justify *how* we study the universe, not just *what* we know.

This course is approved for UC "e" credit as elective in physical science.

I. Standards – California State Physics Standards

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).

g. Students know circular motion requires the application of a constant force directed toward the center of the circle.

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 problems in circular motion by using the formula for centripetal acceleration in the following form: a=v2/r.

j.* Students know how to solve problems involving the forces between two electric charges at a distance (Coulomb's law) or the forces between two masses at a distance (universal gravitation).

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:

a. Students know how to calculate kinetic energy by using the formula $E=(1/2)mv^2$.

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).

c. Students know how to solve problems involving conservation of energy in simple systems, such as falling objects.

d. Students know momentum is a separately conserved quantity different from energy.

e. Students know an unbalanced force on an object produces a change in its momentum.

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:

a. 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.

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

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.

b. Students know how to identify transverse and longitudinal waves in mechanical media, such as springs and ropes, and on the earth (seismic waves).

c. Students know how to solve problems involving wavelength, frequency, and wave speed.

d. Students know sound is a longitudinal wave whose speed depends on the properties of the medium in which it propagates.

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 3×108 m/s (186,000 miles/second).

f. Students know how to identify the characteristic properties of waves: interference (beats), diffraction, refraction, Doppler effect, and polarization.

5. Electric and magnetic phenomena are related and have many practical applications. As a basis for understanding this concept:

a. Students know charged particles are sources of electric fields and are subject to the forces of the electric fields from other charges.

b. Students know magnetic materials and electric currents (moving electric charges) are sources of magnetic fields and are subject to forces arising from the magnetic fields of other sources.

c. Students know how to determine the direction of a magnetic field produced by a current flowing in a straight wire or in a coil.

d. Students know plasmas, the fourth state of matter, contain ions or free electrons or both and conduct electricity.

Investigation & Experimentation

A. 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:

1. 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.

2. Identify and communicate sources of unavoidable experimental error.

3. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

4. Formulate explanations by using logic and evidence.

5. Solve scientific problems by using quadratic equations and simple trigonometric, exponential, and logarithmic functions.

6. Distinguish between hypothesis and theory as scientific terms.

7. Recognize the usefulness and limitations of models and theories as scientific representations of reality.

8. Read and interpret topographic and geologic maps.

9. 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).

10. Recognize the issues of statistical variability and the need for controlled tests

11. Recognize the cumulative nature of scientific evidence.

12. Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

13. 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.

14. 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).

Standards – National Science Education Standards

The sun, the earth, and the rest of the solar system formed from a nebular cloud of dust and gas 4.6 billion years ago. The early earth was very different from the planet we live on today.

Interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the earth system.

Stars produce energy from nuclear reactions, primarily the fusion of hydrogen to form helium. These and other processes in stars have led to the formation of all the other elements.

Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. These wavelengths can be used to identify the substance.

The origin of the universe remains one of the greatest questions in science. The "big bang" theory places the origin between 10 and 20 billion years ago, when the universe began in a hot dense state; according to this theory, the universe has been expanding ever since.

Evidence for one-celled forms of life--the bacteria--extends back more than 3.5 billion years. The evolution of life caused dramatic changes in the composition of the earth's atmosphere, which did not originally contain oxygen.
The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life forms.

II. Assessments

Individual Quarter Grades:
Tests and quizzes: 40%
Homework assignments: 30%
Laboratory Activities and Write-ups: 20%
Quarter Project: 10%

First Semester Grade:
First Quarter: 40%
Second Quarter: 40%
Comprehensive Written Final Exam: 20%

Second Semester Grade:
Third Quarter: 40%
Fourth Quarter: 40%
Comprehensive Written Final Exam: 20%

III. Topic of Study – Time Distribution

FIRST SEMESTER - QUARTER 1

UNIT 1- Introduction to Astronomy—Newton's Laws Objectives (14 days)

Students will be able to:

1. State Newton's Three Laws of Motion and use these laws to explain basic principles in astronomy. F=ma

2. Apply the scientific method in a laboratory setting, making use of the concepts of accuracy, precision, and error. % error = (measured value – accepted value)/(accepted value) x 100 %

3. Explain how close stellar distances are measured in astronomy.

4. Calculate the distance to objects using parallax. Distance = Baseline/sinθP

5. Describe the motions of objects in the celestial sphere and explain the reasons for these motions as seen from Earth, including planetary retrograde motion.

6. Explain the science behind common astronomical phenomenon including rarity of eclipses, seasons, equinoxes, lunar phases, and tidal effects.

7. Demonstrate knowledge technical astronomical concepts such as: precession of the equinoxes, the sidereal day versus solar day, tidal locking (synchronous orbits), and celestial bearings.

8. Summarize the important milestones in the history of astronomy.

UNIT 2 – PLANETARY MOTION—KEPLER'S LAWS, GRAVITATION AND CIRCULAR MOTION (14 days)

Students will be able to:

1. State Kepler's Three Laws of planetary motion and give examples of how they apply to our Solar System.

2. Describe how the equality of centripetal force and gravitational force keeps an object in orbit. F=GmM/r2 Fc=mac ac =v2/r Fc =mv2/r

3. Calculate, using Kepler's Third Law, the semi-major axis of an object's orbit, given the period, and vice versa. P2=a3

4. Apply Newton's Law of Universal Gravitation to calculate the gravitational attraction between two bodies. F=GmM/r2

5. Calculate the velocity needed for an object to remain stable in a particular orbit. vorbital=(GM/r)½

6. Determine mathematically the acceleration due to gravity on the surface of other planets, knowing mass and radius. g=GM/r2

UNIT 3 – SOLAR SYSTEM GENESIS—CONSERVATION OF ENERGY AND ANGULAR MOMENTUM (14 days)

Students will be able to:

1. Summarize the major stages in the formation of the solar system, highlighting the transfer and conservation of energy.

2. Describe how the interplay of gravitation and rotation produces a flattened solar system.

3. Calculate, using conservation of angular momentum, the increase in angular velocity as an object is pulled toward the center of the solar system. $L=I_1\omega_1= I_2\omega_2$ $L=m_1v_1r_1=m_2v_2r_2$

4. Explain changes in gravitational, thermal, and kinetic energies during the formation of the solar system. P.E.=mgh K.E.=$\frac{1}{2}mv^2$ K.E=(3/2)kT $\Delta Q=mC\Delta T$

5. Demonstrate knowledge of the fundamental principles of condensation, accretion, gravitational attraction, bombardment, differentiation, and cooling in the process of planet formation.

6. Discuss the major differences between the terrestrial and jovian planets, and account for these differences using solar system formation theory—comparative planetology.

FIRST SEMESTER - QUARTER 2

UNIT 4 – TERRESTIAL PLANETS KINETIC ENERGY OF PARTICLES (14 days)

Students will be able to:

1. Compare and contrast the fundamental characteristics of the terrestrial planets in terms of surface temperature, atmosphere, orbital geometry, albedo, density, surface features, tectonics, cratering, resurfacing factors, history, and core structure.

2. Explain the observed compositions of the terrestrial planets according the latest theories of solar system and planetary formation.

3. Justify mathematically, using temperature, kinetic energy, and escape velocity, the presence and/or absence of an atmosphere on each of the terrestrial planets. $v_{escape}=(2GM/r)^{½}$ K.E.=$½mv^2=(3/2)kT$

4. Explain the mechanisms of temperature regulation on solid surfaced planets, including cooling rates, atmospheres, reflection, Greenhouse Effect, rotation rates, axial tilt, solar distance, biological processes, and albedo, including how atmospheres protect life.

5. Demonstrate knowledge of how magnetic fields and average density give insight into the internal dynamics of a planet.

6. Discuss current theories for the formation of the Moon, and explain synchronous rotations, orbital resonance (compare and contrast Mercury and the Moon).

UNIT 5 – JOVIAN PLANETS—HYDROSTATIC EQULIBRIUM AND GAS LAWS (14 days)

Students will be able to:

1. Compare and contrast the fundamental characteristics of the Jovian planets in terms of temperature at the cloud tops, composition of the atmosphere, colors,

storms, rotation rates, orbital geometry, albedo, density, history, and interior structure.

2. Account for the measured energy radiated from the Jovian planets in comparison to the solar radiation received.

3. Demonstrate knowledge of factors of pressure and temperature that produce hydrostatic equilibrium in the Jovian planets.

4. Explain how magnetic fields and average density give insight into the internal dynamics and composition of these planets.

5. Describe the differences in the moon systems of the Jovian systems and explain how these differences relate to solar system formation.

6. Explain current theories behind the formation of planetary rings, and predict mathematically, using the Roche Limit, where rings could exist.
   Roche Limit = (2.44)(Radius) $F=GmM/r^2$

UNIT 6 – OUTER SOLAR SYSTEM—KINETIC AND GRAVITATIONAL ENERGIES (14 days)

Students will be able to:

1. Explain the orbital dynamics, composition, and origins of comets, meteoroids, asteroids, and Kuiper Belt Objects.

2. Demonstrate knowledge of how the composition of these bodies gives insight into the early nature of the Solar System.

3. Explain the periodic occurrence of meteor showers and meteor storms.

4. Show mathematically how gravitational potential energy is transferred into kinetic energy during a collision, and determine the total energy that can be released during a collision. $P.E.=mgh$ $K.E.=\frac{1}{2}mv^2$

SECOND SEMESTER – QUARTER 3

UNIT 7 – TELESCOPE DESIGN—OPTICAL AND NON-OPTICAL PRINCIPLES (14 days)

Students will be able to:

1. Discuss the variety of astronomical data gathering tools in use today, including non-optical tools, uses of radio telescopes, the process of interferometry, and theoretical limits of resolution. $\alpha=1.22\lambda/D$

2. Explain the phenomenon of reflection and refraction in terms of wave theory.

3. Calculate index of refraction using Snell's Law. $n=\sin\theta_r/\sin\theta_i$

4. Compare the advantages and disadvantages of various telescope designs.

5. Trace a ray diagram through a lens and mirror system.

6. Use the thin lens law to predict image position and size for an optical system.
   $1/f = 1/o + 1/i$ Mag$=i/o$

7. Calculate magnification for common telescopes in use. Mag.$=F_{obj}/F_{eye}$

8. Demonstrate knowledge of telescope usage, including knowledge of celestial coordinates: right ascension and declination. (Ch & Mc p. 12)

UNIT 8 – SOLAR MECHANICS—HEAT AND THERMODYNAMICS (14 days)

Students will be able to:

1. Describe the stages and processes of star formation.

2. Explain the energy source of the Sun in terms of nuclear fusion and Einstein's mass-energy conversion. $E=mc^2$

3. Outline the stages of energy transportation from the core to the surface of the Sun, including radiation and convection zones.

4. Discuss the concept of hydrostatic equilibrium with regard to the steady-state Sun.

5. Relate the Sun's activity, including sunspots, the solar cycle, solar flares, mass ejections, and the solar wind to effects on Earth.

6. Explain the nature of the Sun's magnetic field and its relationship to types of solar activity.

UNIT 9 – STELLAR CLASSIFICATIONS—ELECTROMAGNETIC WAVES AND SPECTROSCOPY (14 days)

Students will be able to:

1. Discuss the nature of electromagnetic radiation, including concepts of propagation, energy transfer, velocity, wavelength, frequency, electromagnetic spectrum, and blackbody radiation.

2. Convert between wavelength and frequency in various units for electromagnetic radiation. $c = f\lambda$ $f = c/\lambda$ $\lambda = c/f$

3. Compare and contrast the appearance, sources, and formation of continuous, emission, and absorption spectra, highlighting the process of electron transitions. Summarize Kirchoff's Laws.

4. Determine the surface temperature of a star using Wien's Law. $\lambda_{max} = 2.90 \times 10^6$ Knm/T

5. Demonstrate knowledge of the relationships between stellar classes and surface temperatures. Explain spectral classifications: OBAFGKM

6. Calculate the absolute magnitude and luminosity of stars from apparent magnitude and distance (parallax angle). $M = m - 5\log(D/10)$ $L = 10^{-(M-4.83)/2.5}$ $L_{\odot}=3.90\times10^{26}$ W

7. Show how masses and sizes of stars are determined. $L=4\pi\sigma R^2T^4$ $L= R^2T^4$ $R=L^{1/2}/T^4$ $R_{\odot}=6.96\times10^5$km $L\alpha M^{3.5}$

8. Explain how Doppler shift and spectral line width can give information on a star's velocity, rotation, temperature, and atmospheric turbulence.

9. Tell how an analysis of star clusters allows us to determine stages of stellar evolution.

10. Discuss the evolution of stars according to initial mass, including stages of core reactions, sizes and luminosities, stellar lifetimes, types of stellar explosions, and creation of neutron stars, pulsars, and black holes.

11. Explain the theory, evidence, and characteristics of Black Holes. Calculate the possible size of Black Holes. $R_{Sch}=2GM/c^2$

SECOND SEMESTER – FOURTH QUARTER

UNIT 10 – GALACTIC CLASSIFICATIONS AND COSMOLOGY—EINSTEIN'S RELATIVITY (14 days)

Students will be able to:

1. Discuss the historical aspects of the Great Debate over the existence of other galaxies.

2. Express an understanding of galactic structure, the interstellar medium, types of nebulae, and dark matter.

3. Classify galaxies according to their overall structure, size, and composition.

4. Using Doppler shifts of spectral lines, determine the recessional velocity of a galaxy. $\Delta\lambda/\lambda_0=v_r/c$

5. Explain how we determine the distances to galaxies and discuss sources of error in such measurements. $\text{Log}(L/L_\odot) = 1.15\Pi + 2.47$ $M = m - 5\log(D/10)$

6. Demonstrate knowledge of the evidence leading to the acceptance of the expanding universe and the Big Bang theory.

7. Tell how Einstein's theories of relativity relate to the possible evolution of the universe.

8. Discuss the open, closed, and flat models of the universe, outlining the precepts of each, and explain how the search for dark matter might be the determining factor.

9. Describe our basic understanding of quasars and active galaxies.

UNIT 11 –SPACE EXPLORATION—PHYSICAL ENGINEERING (14 days)

Students will be able to:

1. Use Newton's Second Law of Motion to calculate the thrust needed for a spacecraft to accelerate at a given rate. $F=ma$

2. Determine the time needed for spacecraft to travel a distance at a given acceleration. $s=v_0t + \frac{1}{2}at^2$

3. Discuss the engineering difficulties of space flight and possible solutions.

4. Outline the history of space exploration, both manned and un-manned, taking into account the scientific, political, and economic aspects of these endeavors.

5. Demonstrate knowledge of the myriad difficulties to be overcome when undertaking space travel: propulsion, navigation, communication, power, life support, structural engineering, and expense.

UNIT 12 –EXOBIOLOGY (14 days)

Students will be able to:

1. Demonstrate knowledge of how each term in the Drake Equation relates to the possible abundance of life in other star systems. $N = R^* f_p n_e f_l f_i f_c L$

2. Discuss common theories regarding the development of life in the universe.

3. List and justify the types of conditions deemed most likely to support life.

4. Explain how the study of extremophyles on Earth can aid in our understanding of how to search for life on other worlds.

IV. Recommended Materials

Recommended Supplemental Reading:
Cosmos, Carl Sagan, Ballantine Books, 1985
Sky and Telescope Magazine
Astronomy Magazine
Physics Today

Instructional Support Materials:
Great Ideas in Teaching Astronomy, Third Edition, Stephen M. Pompea, Brooks/Cole, 2000
Student Observation Guide with Laboratory Exercises, Seeds & Holzinger, Prentice Hall, 1995