Course Description

A. COVER PAGE

1. Course Title Astronomy and Physics Research	**9. Subject Area** ☐ History/Social Science ☐ English ☐ Mathematics ☑ Laboratory Science ☐ Language other than English ☐ Visual & Performing Arts ☐ College Prep Elective
2. Transcript Title / Abbreviation Astronomy and Physics Research	
3. Transcript Course Code / Number 5660	
4. School Deer Valley High School	
5. District Antioch Unified	
6. City Antioch	**10. Grade Level(s)** 9 10 11√ 12√
7. School / District Web Site www.antioch.k12.ca.us/dvhs/	**11. Seeking "Honors" Distinction?** ☐ Yes ☑ No
8. School Course List Contact **Name:** **Title/Position:** **Phone:** **Ext.:** **E-mail:**	**12. Unit Value** ☐ 0.5 (half year or semester equivalent) ☑ 1.0 (one year equivalent) ☐ 2.0 (two year equivalent) ☐ Other: ______________

13. Was this course previously approved by UC? ☐ Yes ☑ No

If yes, check all that apply:

- ☐ Course reinstated after removal within 3 years. Year removed from list? ________
  - Same course title? ☐ Yes ☐ No
  - If no, previous course title? ______________
- ☐ Identical course approved at another school in same district. Which school ? ______________
  - Same course title? ☐ Yes ☐ No
  - If no, course title at other school? ______________
- ☐ Alternative course title for course with identical content at this school
  - Title of previously-approved identical course: ______________
- ☐ Advanced Placement (AP) or International Baccalaureate (IB) course
- ☐ Approved UC College Prep (UCCP) Initiative course
- ☐ Approved P.A.S.S. course
- ☐ Approved ROP/C course. Name of ROP/C? ______________
- ☐ Other. Explain: ______________

14. Is this a re-submission of a course that was previously NOT approved by UC? ☐ Yes ☑ No

15. Is this course modeled after an UC-approved course from another school <u>outside</u> your district? ☑ Yes ☐ No

If so, which school(s)? __Liberty Union HS__and the Hands On Universe program

Astronomy Space Science with a "B" or higher, or Astronomy Earth Science with a "B" or higher, Physics or Chemistry with a B or permission of instructor

17. Co-Requisites

none

18. Brief Course Description

Astronomy and Physics Research is a year-long course which will guide students through a series of authentic research projects involving physics and astronomy. The research projects will either be part of a larger organized project sponsored by a University or science center, or they will be independent projects which address topics determined by the student, teacher and a mentor. The curriculum for the class will cover all of the California Science Content Standards for experimental design, plus topics in depth related to several collaborative projects such as the Lawrence Hall of Science's Hands On Universe, the National Optical Astronomy Observatory's Teacher Leaders in Research Based Science Education, and others. These specific topics will include astronomy, mathematics, and physics content.

B. COURSE CONTENT

Please refer to instructions

19. Course Goals and/or Major Student Outcomes

Students will participate in collaborative learning research projects sponsored by various nationally recognized astronomy education programs, with the ultimate goal of creating and carrying out student directed research for publication in a journal, web site, science fair, or other public venue.

20. Course Objectives

Students will learn how experiments are designed.
Students will design their own experiments and analyze the experiments of others.
Students will learn how astronomers and other scientists gather and reduce data.
Students will learn basic concepts of physics and chemistry.
Students will collect, reduce, and report astronomical observations.
Students will write testable hypotheses suitable for a high school science course or science fair.
Students will learn advanced instrument techniques, recordkeeping, file mangement, data reduction, graphing techniques, and how to construct a scientific research paper.
Students will conduct a scientific research project and present the results in a public setting, and publish the results in a setting beyond the classroom.
Students will learn how to find best-fit curves, estimate error of measurements, how to reduce the error in measurements, and how to control interfering variables in experimental design.

<u>Specific course content</u> related to content standards is detailed in the course outline but includes significant and fundamental core concepts of astronomy and physics including: acceleration, sinusoidal motion, conservation of momentum, gravity, orbits, optics, nuclear physics, spectroscopy, stellar evolution, Newton's Laws, centripetal force, and others.

21. Course Outline

NOTE: A standards to activity matrix is available.

1) Introduction to Experimental Design
   a) Measurements in Physical Science and Astronomy
   b) Random error vs. systematic error
   c) Accuracy vs. Precision
   d) Standard deviation and significance
   e) Detailed analysis of significant figures
   f) Interpolation and Extrapolation

g) Small number statistics

2) Background research (Paper Analysis Activity)
   a) Sources of information ("the literature")
   b) Use of internet research /reliability of sources
   c) Interviewing researchers/seeking a mentor
   d) Establishing a working hypothesis
   e) Understanding independent and dependent variables
   f) Causal relationships vs. correlations
   g) Writing a hypotheses which can be answered
   h) Reading and Writing research papers

3) Data collection
   a) Organizing data
   b) Multi-variable experiments
   c) Tracking interfering variables
   d) Data analysis (Centripetal Force lab)
      i) Best fit lines
      ii) Curve fitting/graph straightening
      iii) Binning and histograms (Radiation lab)
      iv) Interpolation/Extrapolation
      v) Correlation coefficients

4) Tools and Techniques
   a) Video analysis of motion
      i) Basic kinematics (acceleration lab)
      ii) Conservation of momentum (momentum lab)
      iii) Analysis of motion within the Crab Nebula (pending)
   b) Optoelectronic and piezoelectric sensors
      i) Photogates- (Conservation of Energy and sinusoidal motion lab)
      ii) Force and acceleration sensors – (rocket impulse analysis lab)
         (1) Includes numerical integration introduction
   c) Analysis of optical equipment
      i) Determination of plate scale (plate scale lab)
      ii) Determining the figure of a mirror
      iii) Focal length, aperture, Dawe's Limit, collimation (telescope design lab)
      iv) Charge coupled devices (CCDs)
         (1) Comparison to chemical film
         (2) Demonstration of reciprocity failure
         (3) Bloom
         (4) Review "Introduction to image processing" from astro class
         (5) Frequency response ('Q' vs. wavelength)
         (6) Small number statistics revisited
         (7) Construction of color images ("Pretty Pictures" activity)

5) Pre-fabricated Exercises in Experimental Procedure
   a) HOU: Measuring Jupiter's Moons lab
      i) Content: Gravity, ratios, Kepler's laws, curve fitting
   b) TLRBSE: Spectroscopic Analysis lab
      i) Content: Atomic structure, quantum mechanics, Doppler effect
   c) Measuring the distance to the moon through parallax lab
      i) Content: Geometry application, plate scale, coordinate transforms
   d) TLRBSE: Distribution of novae in M31 as a function of radial distance lab
      i) Purpose: Verification of published experimental results
      ii) Content: Logarithims, brightness ratios, geometry, data reduction

6) Participation in Pre-Existing Experimental Research Projects

Students will participate in at least three of the following projects, and more as time permits.

a) HOU: Supernova Search
b) TLRBSE: Nova search
c) HOU: Asteroid search
d) TLRBSE: AGN Spectroscopy
e) Projects with amateur astronomers
f) Radio telescopy with RA 1420 project
    i) Current research question: Does the angle between Jupiter, Earth and Io affect the strength of radio emissions from Jupiter?

7) Selection and Pursuit of a Research Project *
   a) Project Selection
      The student will:
      i) Recognize own interests, strengths, and resources, and select a relevant, useful topic that solves a problem.
      ii) Research topics in library, news articles, and magazines, and with professionals in the field.
      iii) Evaluate another's research topic.
      iv) Select a topic which can be completed within the constraints of the resources available.
   b) Research Project Proposal
      The student will:
      i) State a purpose.
      ii) Create an experimental procedure which is duplicatable, measurable, and controllable.
      iii) Propose a hypothesis.
      iv) List material ls.
      v) Assess strengths and relate constructive criticism of others.
   c) Library and Internet Research
      The student will:
      i) Research, evaluate, organize, and synthesize library and internet information.
      ii) Identify source, prepare questions, an interview or correspond with a professional in the field.
      iii) Take notes on chosen topic and speech.
      iv) Write an extensive research paper on the available literature on their chosen topic.
      v) Write bibliography of paper.
   d) Experimental Research Paper
      The student will:
      i) Synthesize purpose, review of literature, hypothesis materials, procedure, results, and conclusion.
      ii) Write a formal paper on the completed project.
      iii) Formally and orally present entire project.
      iv) Publish the paper either in the TLRBSE research journal, the web site www.AstronomyTeacher.com, a public science fair, or other non-classroom venue as appropriate.

* Adapted from Liberty USHD Advanced Bio Research course posted at www.ucop.edu.

22. Texts & Supplemental Instructional Materials

Hands On Universe materials from the Lawrence Hall of Science

Discovering Image Processing from the Center for Image Processing in Education

Conceptual Astronomy by Jeff Adkins (publication pending)

23. Key Assignments

1) Physics and Astronomy Labs (all required)
   a) Centripetal Force Lab
   b) Pendulum Lab
   c) Rocket Lab
   d) Telescope design lab
   e) CCD resolution lab
   f) Spectroscopy lab
2) Research Projects (At least 2 required)
   a) HOU: Supernova Search
   b) TLRBSE: Nova search
   c) HOU: Asteroid search
   d) TLRBSE: AGN Spectroscopy
   e) Projects with amateur astronomers
   f) Radio telescopy with RA 1420 project (Deer Valley's Radio Telescope project)

3) Selection and Pursuit of a Research Project *

24. Instructional Methods and/or Strategies

The course will make a gradual transition from guided laboratory activities through activities which give the students an increasing amount of responsibility for deciding the experimental procedure. The hierarchy below, which is based on presentations made by the course author while employed at the Kentucky Department of Education and the National Center on Education and the Economy, establishes a guided metacognitive sequence through which students will experience all of the listed stages of active learning:

- Passive learning: Lectures and demonstrations will be used to introduce new material.
- Reactive learning: Students will be asked to recall key facts and respond with standard procedures for fixed types of problems, such as word problems. Some of the pre-designed research activities fall into this category.
- Active learning: Students will be asked to participate in the learning process by making decisions about the process used to complete a lab activity, such as identifying and controlling interfering variables in a procedure.
- Interactive learning: Students will design procedures for teacher-selected, but relatively simple physical science phenomena such as centripetal force. Students will select variables to investigate, consider sources of interference, analyze results and revise procedures to obtain better results.
- Proactive learning: Students will be asked to design an entire investigation, including determining the research question, experimental variables, sources of interference, proper selection of instruments, and analysis of results, using the teacher or a professional scientist as a mentor.

25. Assessment Methods and/or Tools

The course author is the former Director of Assessment for the National Center for Education and the Economy, and will consequently employ a number of different assessment methods for the course including scoring rubrics for laboratory writeups, multiple-choice examinations for content area and standards based questions, rubric-based oral evaluations of research results, student presentations in a poster session at the school's open house, student-written assessments designed to teach students about the principles of assessment design, and many others.

C. HONORS COURSES ONLY

Please refer to instructions

26. Indicate how this honors course is different from the standard course.

D. OPTIONAL BACKGROUND INFORMATION

Please refer to instructions

27. Context for Course (optional)

This course was developed as a part of Deer Valley High Schools Specialized Secondary Program (SSP) grant awarded by the California Department of Education. This grant provides for the establishment of a Space Academy called the Antioch Space and Astronomy Center for Education, focusing on Earth and Space sciences. The intent is to provide additional electives to encourage students to take additional science elective courses beyond (not necessarily to replace) the traditional science electives students take in high school. The course prerequisite, Astronomy and Space Science, has been taught for several years at DVHS and has enjoyed consistent growth over several years. Two other courses were proposed and approved by the Antioch Unified School District as a part of this grant. They are a Planetarium Production course and a Marine Science course, which will be submitted to UC for evaluation separately.

28. History of Course Development (optional)

The research course is based on three primary sources of information. First, the Lawrence Hall of Science Hands On Universe program provides students with the opportunity to request images to be taken by a professional astronomer and delivered through the internet to the classroom. These images can be used to establish a data base of information for scientific investigation. Hands on Universe students have discovered asteroids and participated in searches for new supernovae in the past. Students select galaxies to target and compare images to determine the presence of supernovae.

A similar program is run by the University of Arizona. This program, called Teacher Leaders in Research Based Science Education, provides original source images for several different ongoing student research in solar phenomena and nova searches within the Andromeda Galaxy. Each year additional images are added to the library to bring new opportunites for discovering novae to the participating schools. In addition, training is provided during an online course and two week workshop in the development of a research-based high school course.

This course is based on an amalgam of the author's experience and the principles and projects from these two projects, both of which have provided exceptional experiences for teachers and students for many y ears.

Additional information on the presentation of experimental design was obtained from Liberty High Schools Bio Research course, posted as an example of how to structure a research class for UC credit at the UCOP/Pathways site.

When the State of California awarded DVHS a SSP planning grant in the late spring of 2002, part of the funds were designated for writing course proposals for new courses. In collaboration with other teachers in the Space Academy program, this course was developed to meet a particular need for advanced students and to encourage other teachers to pursue research-based science education. A survey conducted at the time the grant was written indicated at least one section of the course would be needed to meet demand.