CALIFORNIA STATE POLYTECHNIC UNIVERSITY, POMONA

ACADEMIC SENATE

GENERAL EDUCATION COMMITTEE

REPORT TO

THE ACADEMIC SENATE

GE-071-156

AST 3420 – Life, the Universe, and Everything (GE Area B5)

General Education Committee	Date: 06/29/2016
Executive Committee Received and Forwarded	Date: 08/17/2016
Academic Senate	Date: <u>08/31/2016</u> <u>First Reading</u>

BACKGROUND:

This is a revisioned course.

RESOURCES CONSULTED:
Faculty
Department Chairs
Associate Deans
Deans
Office of Academic Programs

DISCUSSION:

The GE Committee reviewed the ECO for this course and found it to satisfy the GE Student Learning Outcomes and other requirements for GE Area B5.

RECOMMENDATION:

The GE Committee recommends approval of GE-071-156, AST 3420 – Life, the Universe, and Everything for GE Area B5.

AST - 3420 - Life, the Universe, and Everything
C. Course - New General Education* Updated

General Catalog Information

College/Department	**Physics and Astronomy**
Semester Subject Area	**AST**
Semester Catalog Number	3420
Quarter Subject Area	**PHY**
Quarter Catalog Number	303
Course Title	Life, the Universe, and Everything
Units*	**(3)**
C/S Classification *	**C-02 (Lecture Discussion)**

To view C/S Classification Long Description click: http://www.cpp.edu/~academic-programs/scheduling/Documents/Curriculum%20Guide/Appendix_C_CS_Classification.pdf

Component*	**Lecture**
Instruction Mode*	**Face-to-Face**
Grading Basis*	**Graded Only**
Repeat Basis*	**May be taken only once**

If it may be taken multiple times, limit on number of enrollments	**1**

Cross Listed Course Subject Area and Catalog Nbr (if offered with another department)	

Dual Listed Course Subject Area and Catalog number (If offered as lower/upper division or ugrd/grad)	

Choose appropriate type (s) of course(s)*	☐ Major Course ☐ Service Course ☑ GE Course ☐ None of the above

General Education Area / Subarea*	**B5**

To view the General Education SubArea definitions, click http://www.cpp.edu/~academic-programs/scheduling/Documents/Ch.3-GeneralEducationProposals.pdf.

I. Catalog Description

Catalog Description	An examination of the origins of life in the universe based on astronomy, cosmology, biology, and planetary science. Topics may include the search for extraterrestrial intelligence (SETI), the history of life in our solar system, and the origins of the chemical elements through Big Bang nucleosynthesis and 'galactic recycling plants.

II. Required Coursework and Background

Prerequisite(s)	Prerequisite: GE courses in areas A1, A2, A3, B1, B2, B3, B4

Corequisite(s)

Pre or Corequisite (s)

Concurrent

III. Expected Outcomes

List the knowledge, skills, or abilities which students should possess upon completing the course.*

On successful completion of this course, students will be able to:

1. Use words, simple equations, and (when appropriate) graphs to correctly explain:

a. The relationship between the size, temperature, energy output, and spectral peak of a main sequence star.
b. The relationship between the temperature of a star, its surface area, its distance from earth, and the apparent brightness of the star to an observer on earth.
c. The role that angular momentum plays in the evolution of a solar system from a disk of dust and gas to a star surrounded by planets.

2. Identify chemical elements and compounds that are essential to the formation of potentially habitable worlds, as well as the different stellar processes involved in the formation of these compounds.
3. Identify the types of chemicals and signals that would be consistent with the presence of life (whether unicellular or otherwise) on another planet and would be detectable from earth.
4. List places in our solar system that are candidates for harboring non-terrestrial life, and the evidence that makes these places plausible candidates in the opinions of many researchers.
5. Compare and contrast common responses to the Fermi paradox concerning the lack of received signals from other technological civilizations, and the possible implications for the future of human technological civilizations.

If this is a course for the major, describe how these outcomes relate to the mission, goals and objectives of the major program.	

Explain how the course meets the description of the GE SubArea(s). Please select appropriate outcomes according to the GE Area/SLO mapping.	The topics of this course, roughly falling under the heading of “astrobiology”, are inherently interdisciplinary, spanning biology (to understand the essential building blocks of life), astronomy (the tools for detecting possible evidence of life beyond our planet and distinguishing between signatures of biology and signatures of non-biological processes in the cosmos), nuclear physics (the prerequisites for the formation of the heavy elements essential to any biological process that we can conceive of) and even engineering (understanding the

magnitude and pattern of radio signals that might plausibly be produced by a technological civilization). Moreover, the question of how life came to arise on earth is of timeless cultural significance, being central to countless religions and creeds, and a dominant theme in debates over the roles of science and religion in modern society. While it is not the purpose of this course to delve into religious debates, any discussion of the scientific evidence concerning the origin of life and its prerequisites is inevitably touching on a topic of inherent cultural and social relevance, thus bringing insights of multiple modern scientific disciplines into discussions in the humanistic fields, in keeping with the intent of an interdisciplinary synthesis course.

HOW THE COURSE MEETS THE GUIDELINES FOR GE SYNTHESIS COURSES

The major focus of a synthesis course is to integrate and focus fundamental concepts and issues. Each course in this category shall:

- Include readings from original primary/historical sources, as opposed to only secondary sources.

  Textbook readings will be supplemented by readings from the research literature in astronomy and astrobiology. While it is not expected that undergraduate students in a general education course will be able to digest every word of technical articles written for professionals, students will be assigned to examine specific portions of carefully-selected articles, especially figures that illustrate concepts presented in class. The goal of these assignments is to help students develop comfort in examining scientific literature outside of their professional specialization.

- Promote original and critical thinking in writing and/or discussion.

  Students will have multiple writing assignments in which they will produce short to medium length to respond to an argument about a scientific concept, and will explain why that argument is or isn't consistent with available evidence. Additionally, students will, as individuals or in small groups, give oral presentations in which they will discuss a significant area of investigation in the field of astrobiology, and the significance of evidence that has either been published in peer-reviewed literature or is currently being gathered by an ongoing astronomical mission or observational instrument under construction.

- Focus attention on understanding the interrelationships among the disciplines and their applications.

  See the paragraph above concerning the interdisciplinary nature of astrobiology.

- Examine ideas and issues covered in this area in deeper and/or broader more integrative ways.

  Students will go beyond the interpretation of specific facts or observations in isolation, and will also focus on the problem of incomplete information concerning the possibility of life beyond our planet. For instance, a portion of the course will be spent on evidence that most of the solar systems detected thus far are very different from our own, contrast that with the fact that the star we orbit is of an unremarkable type, and then reconcile these observations via the fact that the tools available for detecting planets are (for now) mostly sensitive to solar systems very different from our own. Students will, by the end of the course, be able to explain the lines of evidence for those three facts. Likewise, students will, by the end of the course, be able to explain why certain places in our solar system are considered plausible candidates for harboring past or present extra-terrestrial life, and will also be able to explain what sorts of evidence would have to be collected in order to verify such a hypothesis, as well as the reasons why such evidence has thus far been difficult to collect.

- Encourage synthetic-creative thinking in order to identify problems, understand broader implications and construct original ideas.

  See response to the previous item.

- Identify and evaluate assumptions and limitations of ideas and models.

  See response to item above, on deeper and more integrative approaches. Students will spend considerable time on questions for which the answer is not yet known, and will focus on identifying the limitations of existing observational and measurement techniques, as well as the uncertainties in the predictions of models for the formation of plausibly habitable worlds.

- Develop written and oral communication skills appropriate for an upper division course (completion of courses in Area A: Subareas A1, A2, & A3 is required.)

  See meaningful writing assignment in section IX of this ECO.

- Provide student work for assessment of the student's understanding of the required educational objectives in this subarea or in this course.

  See Section IX of this ECO

- The relationship between science, technology, and civilization

  Key course topics will include:

  - The cultural interest in the question “Are we alone?”
  - Scenarios for future technology and communication, as well as the sustainability of advanced technological civilizations, and the

implications of these scenarios for the prospects of detecting signals from advanced civilizations in other star systems.

- The effect science and technology have on culture and human values.

  See previous item.

- The application and generalization of basic scientific or quantitative knowledge from the foundational courses to real world or practical problems

  Analyzing the prerequisites for the formation of a habitable world will draw on and extend knowledge of biology from the students' B2 courses, knowledge of the physical sciences from the students' B1 courses, and quantitative skills developed in B4. Analyzing the strengths and limitations of observational techniques will draw on the facility with measurement and data analysis developed in the B3 course.

Describe how these outcomes relate to the associated GE Learning Outcomes listed below.*

Ia) Write effectively for various audiences.

Students will produce short essay answers to conceptual questions on homework assignments and exams. Additionally, students will produce 1-2 page essay responses to questions about selected readings.

Ib) Speak effectively for various audiences.

Students will give individual or small-group presentations on a topic in astrobiology.

Ic) Find, evaluate, use and share information effectively and ethically.

Students will analyze information from primary sources (particularly graphs and data) to answer homework questions. Students will find their own information sources for their final class presentation.

Id) Construct arguments based on sound evidence and reasoning to support an opinion or conclusion.

Students will answer conceptual questions on homework and exams, in which they will apply basic principles of physics to reach conclusions about astronomical phenomena. In addition, they will produce essays in which they will cite specific examples from the readings to respond to a question about the evidentiary basis about a claim in astronomy or astrobiology.

Ie) Apply and communicate quantitative arguments using equations and graphical representations of data.

Students will answer conceptual questions on homework assignments and exams, requiring them to use simply physics equations to draw quantitative conclusions about the relationships between different variables or measurements.

IIa) Apply scientific methods and models to draw quantitative and qualitative conclusions about the physical and natural world.

Students will answer conceptual questions on homework assignments and exams, requiring them to use simply physics equations to draw quantitative conclusions about the relationships between different variables or measurements. They will also answer questions about the meaning of quantitative data taken from primary sources.

IId) Integrate concepts, examples, and theories from more than one discipline to identify problems, construct original ideas, and draw conclusions.

The search for life in the universe draws on the knowledge and methods of biology, astronomy, physics, and engineering.

General Education Outcomes*

Ia. Write effectively for various audiences

Ib. Speak effectively to various audiences.

Ic. Find, evaluate, use, and share information effectively and ethically.

Id. Construct arguments based on sound evidence and reasoning to support an opinion or conclusion.

Ie. Apply and communicate quantitative arguments using equations and graphical representations of data.

IIa. Apply scientific methods and models to draw quantitative and qualitative conclusions about the physical and natural world.

IId. Integrate concepts, examples, and theories from more than one discipline to identify problems, construct original ideas, and draw conclusions.

To view the mapping, click https://www.cpp.edu/~academic-programs/Documents/GE%20SLO%20Mapping.pdf

IV. Instructional Materials

Provide bibliography that includes texts that may be used as the primary source for instruction, and other appropriate reference materials to be used in instruction. The reference list should be current, arranged alphabetically by author and the materials should be listed in accepted bibliographic form.

Instructional Materials*

Texts may vary with instructor and over time, but will be at the level and breadth of Bennett & Shostak, *Life in the Universe*, 3rd Edition (2011).

Primary sources might include:

Astronomy, planet formation, and planetary search references:

1. Looking for Earths, A. Boss, John Wiley & Sons, Chap. 4. (1998)
   A popular level introduction to the standard theory of planet formation . The entire book is a good read for the history of the subject. It also contains many good references in the back.
2. 'Extrasolar Planets', A.P. Boss, *Physics Today* 49 (1996): 32.

A shorter and slightly more technical version of the first reference.

3. 'The Formation and Habitability of Extra-Solar Planets', G.W. Wetherill, *Icarus* 119 (1996): 219.

An excellent overview of the standard star and planet-formation scenario with application to the likelihood of finding habitable planets around other stars.

4. 'Extrasolar Planets Around Main Sequence Stars', G.W. Marcy, W.D. Cochran, & M. Mayor, *Protostars and Planets IV*, ed. V. Mannings, A. Boss, and S. Russell (2000).
This review article by the two of the first people to discover extra-solar planets discusses the techniques used and some of the possible selection effects. It also briefly talks about planetary migration.

5. 'Orbital migration of the planetary companion of 51 Pegasi to its present location', Lin, D.N.C., Bodenheimer, P., & Richardson, D.C., *Nature* 380 (1996): 606.

This is the original paper which proposed how the first detected extra-solar planet came to be so close to its star. It mentions the concept of orbital migration, the idea that Jupiter-like planets may not stay put, depending on the conditions under which they form, but also proposes a way to keep them from being completely absorbed in the parent star.

6. 'Survival of Planetary Systems', W.R. Ward, *Astrophysical Journal* 482 (1997): L2.
This paper proposes that many Earth-like planets may be destroyed, either by a 'Jupiter' spiraling in, or by spiraling into the star themselves.

Social and cultural significance of the question 'Are we alone?'

1. Chyba, C.F. and Hand, K.P., Astrobiology: The study of the living universe, *Annual Review of Astronomy and Astrophysics,* 43, 31-74, 2005
2. Jakosky, B.M., Philosophical aspects of astrobiology, in *Bioastronomy '99: A New Era in Bioastronomy,* G.A. Lemarchand and K.J. Meech, eds. Astronomical Society of the Pacific, 661-666, 2000
3. Jakosky, B.M., and Golombek, M.P., Planetary science, astrobiology, and the role of science and exploration in society, *EOS, Transcripts of the American Geophysical Union,* **81,** 58, February 6, 2000

Lectures, lecture notes, and current papers on the diverse topics will also be made available on BlackBoard by the instructor.

Faculty are encouraged to make all materials accessible. Indicate with an asterisk those items that have had accessibility (ATI/Section 508) reviewed. For more information, http://www.cpp.edu/~accessibility

V. Minimum Student Material

List any materials, supplies, equipment, etc., which students must provide, such as notebooks, computers, internet access, special clothing or uniforms, safety equipment, lockers, sports equipment, etc. Note that materials that require the assessment of a fee may not be included unless the fee has been approved according to University procedures.

Minimum Student Material*

V. Minimum Student Material

• Computer (as needed)
Internet service
e-mail
calculator
notebook

VI. Minimum College Facilities

List the university facilities/equipment that will be required in order to offer this class, such as gymnastic equipment, special classroom, technological equipment, laboratories, etc.

Minimum College Facilities*

VI. Minimum College Facilities

External Support

Library Services
Stockroom
Graphic Services
Information Technology (IT) Services
Classroom Management System (e.g. BB)
copier

Physical Space & Major Equipment

lecture room with seating for up to 40 students
smart classroom (computer/projector)
periodic chart
overhead screen
white board/dry erase markers
adjustable lighting

VII. Course Outline

Describe specifically what will be included in the course content. This should not be a repetition of the course description but an expansion that provides information on specific material to be included in the class, e.g. lecture topics, skills to be taught, etc. This should not be a week-by-week guide unless all instructors are expected to follow that schedule.

Course Outline*

Course topics:

1. Main sequence stars: The most common star systems
    a. Observational evidence: Temperature, mass, luminosity, and spectrum.
    b. Capabilities and limitations of the telescopes used image them.
2. Star formation and protoplanetary disks
3. The ingredients of life and planets: Formation of elements by nuclear fusion from the Big Bang to now.
4. Extrasolar planets:
    a. Detection techniques: Doppler shifts, transits, and beyond
    b. Hot Jupiters: The most common planets in the first batch found
    c. Plausibly rocky planets and prospects for the future
5. Signatures of habitable worlds: Chemicals that are recycled by biology
6. Our own solar system:
    a. Possibilities of extraterrestrial life in the past, and prospects for detection
    b. Subsurface oceans as possible refuges for current life, and prospects for detection
    c. The weird weather and chemistry of Titan
7. The search for extraterrestrial intelligence:
    a. The Fermi paradox and the Drake equation
    b. Searches for radio signals and other electromagnetic signatures
8. Are we alone and do we care
    a. The cultural significance of loneliness or neighborliness
    b. Significance for our future: Do technological civilizations last?

VIII. Instructional Methods

Describe the type(s) of method(s) that are required or recommended for the instruction of this course (lectures, demonstrations, etc.). Include any method that is essential to the course, such as the use of particular tools or software.

Instructional Methods*	Lecture Problem-solving Discussion Seminar Small-group activities Student presentations (small group or individual) Review, evaluation, critique Assigned readings (textbook, journals, primary reading etc.)

IX. Evaluation of Outcomes

Describe the methods to be used to evaluate students' learning, i.e. written exams, term papers, projects, participation, quizzes, attendance, etc.*	Students' learning of course content is evaluated via the following work: 1. Homework assignments, including a mix of conceptual questions (paragraph-long answers), short calculations, interpretation of graphs and data (calculations and paragraph-long answers and/or short calculations). Homework will typically be assigned either weekly or every other week. The questions will be based on a mixture of material from the textbook, material from primary sources (especially graphs and data), and material presented during lectures and class discussions. 2. Short essays in response to readings (including primary sources and the textbook), typically at the beginning or end of a unit. Essays will be 1.5-2 pages, and approximately 3-5 will be

assigned per semester. Students will receive feedback in the form of written comments before the next essay is assigned.

3. Midterm and final exams, consisting of a mix of conceptual questions (paragraph-long answers), short calculations, interpretation of graphs and data (calculations and paragraph-long answers and/or short calculations).
4. An oral presentation to the class (either individual or small group), in which students will discuss a significant area of investigation in the field of astrobiology, and the significance of evidence that has either been published in peer-reviewed literature or is currently being gathered by an ongoing astronomical mission or observational instrument under construction. If discussing ongoing investigations that have not yet released peer-reviewed results, students will be expected to cite information on capabilities publicly disclosed by the investigators, and compare these capabilities with previous peer-reviewed investigations or with theoretical estimates in peer-reviewed literature.

Describe the meaningful writing assignments to be included.*

Student's writing will be assessed via a combination of paragraph-long answers to conceptual questions on tests and homework assignments, and short essays responding to questions related to the readings (particularly but not exclusively primary sources.) The essays will typically be 1.5-2 pages, 3-5 will be assigned per semester, and the essays will be graded both for the quality of the reasoning and evidence and also the quality of the writing.

Discuss how these methods may be used to address the course and program outcomes, as appropriate. Include or attach a matrix to align the evaluation methods to the outcomes.*

	Homework	Essays	Exams	Presentation
Course SLO 1a: Use words, simple equations, and (when appropriate) graphs to correctly explain the relationship between the size, temperature, energy output, and spectral peak of a main sequence star.	x		x	Depends on topic chosen

Course SLO 1b: Use words, simple equations, and (when appropriate) graphs to correctly explain the relationship between the temperature of a star, its surface area, its distance from earth, and the apparent brightness of the star to an observer on earth.	x		x
Course SLO 1c: Use words, simple equations, and (when appropriate) graphs to correctly explain the role that angular momentum plays in the evolution of a solar system from a disk of dust and gas to a star surrounded by planets.	x	x	x
Course SLO 2: Identify chemical elements and compounds that are essential to the formation of potentially habitable worlds, as well as the different stellar processes involved in the formation of these compounds.	x		x
Course SLO 3: Identify the types of chemicals and signals that would be consistent with the presence of life (whether unicellular or otherwise) on another planet and would be detectable from earth.	x	x	x
Course SLO 4: List places in our solar system that are candidates for harboring non-terrestrial life, and the evidence that makes these places plausible candidates in the opinions of many researchers.	x	x	x
Course SLO 5: Compare and contrast common responses to the Fermi paradox concerning the lack of received signals from other technological civilizations, and the possible implications for the future of human technological civilizations.	x	x	x

If this is a general education course, discuss how these methods may be used to address the associated GE Learning Outcomes listed below. Include or attach a matrix to align the evaluation methods to the outcomes.*

	GE SLOs						
Assessment Method	**Ia**	**Ib**	**Ic**	**Id**	**Ie**	**IIa**	**IId**
Homework	X		X	X	X	X	X
Essays			X	X	X	X	X
Exams	X			X	X	X	X
Presentations			X	X	X	X	X

X. This OPTIONAL Section is for describing Course/Department/College specific requirements.

Department/ College Required ECO Information (Optional)