



SENATE COMMITTEE ON CURRICULAR AFFAIRS
COURSE SUBMISSION AND CONSULTATION FORM

Principal Faculty Member(s) Proposing Course

Name	User ID	College	Department
DEREK FOX	dbf11	Science (SC)	Not Available
ERIC HAYOT	EUH2	Liberal Arts (LA)	Not Available

Academic Home: Science (SC)

Type of Proposal: Add Change Drop

Course Designation

(ASTRO 19N) Being in the Universe

Course Information

Cross-Listed Courses:

CMLIT 19N(LA)

Prerequisites:

Corequisites:

Concurrents:

Recommended Preparations:

Abbreviated Title: Being in the Univ
Discipline: General Education
Course Listing: Inter-Domain

Special categories for Undergraduate (001-499) courses

Foundations

- Writing/Speaking (GWS)
- Quantification (GQ)

Knowledge Domains

- Health & Wellness (GHW)
- Natural Sciences (GN)
- Arts (GA)
- Humanities (GH)
- Social and Behavioral Sciences (GS)

Additional Designations

- Bachelor of Arts
- International Cultures (IL)
- United States Cultures (US)
- Honors Course
- Common course number - x94, x95, x96, x97, x99
- Writing Across the Curriculum

First-Year Engagement Program

- First-Year Seminar

Miscellaneous

Common Course

GE Learning Objectives

GenEd Learning Objective: Effective Communication

GenEd Learning Objective: Creative Thinking

GenEd Learning Objective: Crit & Analytical Think

GenEd Learning Objective: Global Learning

GenEd Learning Objective: Integrative Thinking

GenEd Learning Objective: Key Literacies

GenEd Learning Objective: Soc Resp & Ethic Reason

Bulletin Listing

Minimum Credits:	3
Maximum Credits:	3
Repeatable:	NO
Department with Curricular Responsibility:	Astronomy And Astrophysics (UPSC_ASTRO)
Effective Semester:	Upon Approval
Travel Component:	NO

Course Outline

A brief outline or overview of the course content:

"Being in the Universe" considers three fundamental questions of human existence from both humanistic and scientific perspectives: (1) What is the nature of our universe, and to what extent are creatures like ourselves a predictable consequence of it? (2) What is the nature of time, and what are the implications of living in or through time? (3) What would it mean for humans to be alone in the Galaxy or the universe, or alternatively, not alone? "Being in the Universe" is an integrative GH+GN GenEd course.

A listing of the major topics to be covered with an approximate length of time allotted for their discussion:

In response to a number of comments made in consultation, we want to emphasize that the list of topics and sample syllabus below are meant to indicate in broad outlines one possible version of this course. The exact readings and sequence of assignments or exams would be determined by the individual instructor(s) of the course. We have in many cases put more ideas down than any single iteration of the course could offer, with the idea that these may provide some inspiration to others who might wish to teach it, and with the understanding that no one could or should attempt to teach ALL of these things.

Unit I. Being in a Universe

Week 1: Cosmology as a Human Enterprise

We discuss cosmology as a quest to understand and explain the human environment that has extended, across cultures, from ancient times to the present. What are the fundamental cosmological questions? Why do human cultures ask them? How have they gone about answering them? Readings include material from "The Cosmic Perspective: Fundamentals" (Bennett et al., Pearson Higher Ed.), a standard textbook in astronomy, together with readings from original ancient sources on cosmology (Babylonian and Meso-American star maps and mythologies, the Torah, Chinese creation myths) and secondary source readings on the history of cosmology (Nicholas Campion, "Astrology and Cosmology in the World's Religions")

Week 2-3: A Big Bang Universe; The Past and Future of our Universe

We present and explore the modern, post-Einsteinian understanding of cosmology, in two ways: (1) We look at the historical moment in which Einstein, Hubble, and subsequent astronomers developed and tested the theory of an expanding "Big Bang" universe, using texts and historical sources and reviewing the key observational evidences for the Big Bang; (2) We place students within the cosmic context of the Big Bang model, locating Earth in physical and temporal space and exploring the inferences as to the distant past, and the implications for the distant future, that result.

Weeks 4-5: Beyond the Big Bang

These weeks focus on the arguments for and philosophical implications of "cosmic inflation" and scientific theories of the multiverse, and debates over the anthropic principle. We will read material from contemporary scientific thinkers and writers (Sean Carroll; Sabine Hossenfelder; Steven Weinberg), literary texts focused on the problems of the multiverse (Borges, "The Garden of Forking Paths"), and texts of literary/philosophical criticism (Mary Jane Rubenstein, "Worlds Without End: The Many Lives of the Multiverse").

Exam 1 is held at the end of the unit.

Unit II. Being in Time

Weeks 6-7: Time as Change; Time and Spacetime

These weeks elucidate the modern scientific understanding of time, in two distinct phases: First, exploring how the "arrow of time" (time as change) arises from thermodynamic considerations in far-from-equilibrium systems, including the universe; and next, exploring how Einstein's theories of special and general relativity cause the previously distinct concepts of "space" and "time" to merge into a single "spacetime" – most dramatically, under the influence of high relative velocities, large accelerations, and/or strong gravitational fields. Both sections draw on the previously established concept of the Big Bang universe, now seen to offer the ultimate stage for both time as change, and time as spacetime, to play itself out.

Weeks 8-10: Philosophies of Spacetime; Visions of Time

We next treat these topics from a humanistic perspective, considering historical philosophies of time, including cosmological theories of eternal return (Eliade), phenomenological accounts of time (Bergson), before proceeding to contemporary philosophical

debates including presentism vs. eternalism, the relation between the future and the past, and implications of the human experience of time. We show how philosophical accounts have been affected by scientific developments and vice versa; we consider narratives and theories of time travel.

We then explore the experience of time through nonfictional and imaginative works. Is or can the human experience of time be independent of the physical nature of time? How would an artificial intelligence experience time? Why does some time feel long, and some time feel short? What is the relationship between memory and time, between anticipation and time? What is the nature of the "present"? What are the implications for human life of the universe's relation to time, and how have various cultures theorized or managed that experience? We consider the impact of scientific theories (including the theory of relativity) on popular conceptions of time, introducing science fiction depictions of time travel, wormholes, and other violations of causality.

Exam 2 is held at the end of the unit.

Unit III. Being Alive

Weeks 11-12: What is Life?; Life in the Solar System

We explore the challenge of constructing a working definition of life, examining Erwin Schrödinger's famous essay on the topic before reviewing the history of life on Earth (so far as it is known) and the multitudinous forms of life on this planet. We then proceed to explore the prospects for life elsewhere in the Solar System, both in the distant past and today. Finally, we consider the prospects for human settlement of other worlds within our Solar System.

Weeks 13-15: Life among the Stars; Alone in the Anthropocene

We review the methods by which astronomers discover and characterize planets in orbit around distant stars, and consider how we might study these planets for evidence of life. We consider the prospects for life of varying degrees of complexity, and longevity, across these many worlds, addressing the prospects for civilized life specifically via the Drake Equation and the Fermi Paradox, aka the Great Silence. We consider these arguments in tandem with Bostrom's simulation trilemma and other philosophical and scientific claims regarding alien life.

We explore some of the voluminous philosophical and literary histories of the imagination of alien or monstrous life, including material from literature (The Odyssey, Gulliver's Travels, War of the Worlds, Roadside Picnic, for example), film (2001, Contact, and also Predator, Starship Troopers, for example), and television (Star Trek, Battlestar Galactica, for example).

We conclude the course lectures with a discussion of "Life in the Anthropocene," connecting the key course themes to the present geological moment and its various environmental crises, as well as to the existential dilemmas of being human. These lead us to reflect together on the possible futures for our civilization, and life on Earth.

The course concludes with selected project presentations and a final exam.

Course Description:

"Being in the Universe" considers three fundamental questions of human existence from both humanistic and scientific perspectives: (1) What is the nature of our universe, and to what extent are creatures like ourselves a predictable consequence of it? (2) What is the nature of time, and what does it mean to be a conscious being living our lives through time? (3) What would it mean for humans to be alone in the Galaxy or the universe, or alternatively, not alone? "Being in the Universe" is an integrative GH+GN GenEd course.

The course's three major units cover the following topics: (1) We discuss cosmology and religion as human enterprises, as well as the history of science; (2) We study the basic scientific theory of the Big Bang universe, and consider its implications for human life; (3) We address contemporary theories of the multiverse from scientific, philosophical, and literary perspectives; (4) We consider the thermodynamic and relativistic theories of time, and the basic philosophical approaches to time, and discuss the implications of these for our ordinary human experience of the past, present, and future; (5) We discuss the history of life in the universe, the possibility of life on other planets, and the social, religious, and imaginative reactions to those possibilities in literature and film.

The name(s) of the faculty member(s) responsible for the development of the course:

| Name: DEREK FOX (dbf11)

Title:

Phone:

Address:

Campus: UP

City:

Fax:

| Name: ERIC HAYOT (EUH2)

Title:

Phone:

Address:

Campus: UP

City:

Fax:

Course Justification

Instructional, Educational, and Course Objectives:

This section should define what the student is expected to learn and what skills the student will develop.

The goal of this course is for students to explore our modern understanding of humanity's place in a large yet ultimately finite universe – as both nouns (human beings in a universe) and verbs (humans being in a universe). The three organizing themes illuminating this issue will be addressed from both humanistic and scientific perspectives: Students will learn what is known about each subject and how we came to this knowledge, while developing the tools required to analyze this knowledge, consider and debate its consequences, and apply it within their individual lives. The three major course units each target specific humanistic

fields: history/religion for Unit 1, philosophy for Unit 2, and literature/creative arts for Unit 3. Exploration of these themes will be centered throughout on the basic scientific/astronomical questions, the history of their development and cultural impact, and their implications for our lives.

Specifically, course learning objectives are as follows:

I. Being in a Universe

- o Engage critically with a selection of multicultural historical cosmologies reflecting some of the diversity of human societies, past and present
- o Understand the role that cosmologies have played in (de)centering the human experience within an Earthly/Universal expanse of space and time
- o Be familiar with key historical developments leading to the modern scientific cosmology and its hierarchical structure, Earth < Solar System < Milky Way Galaxy < Universe (< Multiverse)
- o Understand how astronomical observations and theoretical arguments provide evidence for a Big Bang origin of the universe via Cosmic Inflation, and for Dark Matter and Dark Energy
- o Be familiar with current theoretical expectations for the long-term future of the Sun and Earth, the Milky Way, and the universe at large
- o Be familiar with the idea, inspired by cosmic inflation theories, that our universe may be one of many in a larger "multiverse"
- o Understand how the Anthropic Principle can help us understand the properties of Earth and, potentially, those of the universe at large
- o Explore and confront selected literary and imaginative visions of the multiverse

II. Being in Time

- o Understand the two visions of time - (1) Time as a physical dimension; and (2) Time as change - and their reconciliation via Ludwig Boltzmann's statistical mechanics
- o Understand why we experience "time as change" during the present epoch of our universe, and how the approach of the universe to thermal equilibrium will eventually bring an end to the arrow of time and "time as change"
- o Engage with critical and imaginative explorations of "the end of time"
- o Understand that the relativity of space and time implies the relativity of simultaneity, breaking the Newtonian vision of absolute universal time
- o Understand the General Relativistic picture of gravity: "matter tells spacetime how to curve; spacetime curvature tells matter how to move"
- o Understand how time travel might be possible if wormholes or warp drives can exist in our universe
- o Be familiar with the ontologies of selected philosophies of time including Presentism and Eternalism
- o Engage critically with selected literary and imaginative visions of the human experience of time, time travel, and time dilation/suspension

III. Being Alive

- o Debate several possible definitions of life, exploring their advantages, shortcomings, and exceptions
- o Develop a basic knowledge of planetary habitability, the fundamental requirements for life, and the history of life on Earth
- o Understand, in general terms, the prospects for life on other worlds of the Solar System, both today and in its distant past
- o Understand how astronomers discover and study extrasolar planets, search for evidence of life on these planets, and seek to identify evidence of alien civilizations
- o Engage critically with current arguments regarding the possible existence of alien civilizations within the Milky Way galaxy
- o Develop a basic knowledge of the challenges involved in robotic and human exploration of other worlds of the Solar System, and the much greater challenges involved in robotic and human exploration of other stellar systems
- o Engage critically with visions of monstrous and god-like (non-human) beings from selected literary traditions, and with modern literary and imaginative visions of alien civilizations, alien intelligence, and artificial intelligence
- o Be familiar with key ways in which human civilization has altered the geology, geography, and biosphere of Earth
- o Debate the various likely futures for human civilization and Earth life
- o Reflect critically on the meaning of a human life, and human civilization, within its larger cosmic context

Evaluation Methods:

Include a statement that explains how the achievement of the educational objective identified above will be assessed. The procedures for determining students' grades should be specifically identified.

In large lecture-style versions of the course, evaluation will be conducted via exams, online homework assignments, and a group project. Smaller versions of the course may do things differently. Students will be required to complete a telescope observing or planetarium exercise at some point during the semester.

Relationship/Linkage of Course to Other Courses:

This statement should relate the course to existing or proposed new courses. It should provide a rationale for the level of instruction, for any prerequisites that may be specified, or for the course's role as a prerequisite for other courses.

This course is a new GenEd integrative studies course that brings together GH and GN perspectives on matters of critical import to the history and idea of humanity. It has no linked or connected courses.

Relationship of Course to Major, Option, Minor, or General Education:

This statement should explain how the course will contribute to the major, option, or minor and indicate how it may function as a service course for other departments.

This course fulfills either the GN or the GH GenEd option, as well as the integrative GenEd requirement.

A description of any special facilities:

None needed.

Frequency of Offering and Enrollment:

Once a year, with enrollment of 100+.

Alignment with General Education Objectives

EFFECTIVE COMMUNICATION – the ability to exchange information and ideas in oral, written, and visual form in ways that allow for informed and persuasive discourse that builds trust and respect among those engaged in that exchange, and helps create environments where creative ideas and problem-solving flourish.

KEY LITERACIES – the ability to identify, interpret, create, communicate and compute using materials in a variety of media and contexts. Literacy acquired in multiple areas, such as textual, quantitative, information/technology, health, intercultural, historical, aesthetic, linguistic (world languages), and scientific, enables individuals to achieve their goals, to develop their knowledge and potential, to lead healthy and productive lives, and to participate fully in their community and wider society.

CRITICAL AND ANALYTICAL THINKING – the habit of mind characterized by comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating a conclusion. It is the intellectually disciplined process of conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

INTEGRATIVE THINKING – the ability to synthesize knowledge across multiple domains, modes of inquiry, historical periods, and perspectives, as well as the ability to identify linkages between existing knowledge and new information. Individuals who engage in integrative thinking are able to transfer knowledge within and beyond their current contexts.

CREATIVE THINKING – the capacity to synthesize existing ideas, images, or expertise in original ways and the experience of performing, making, thinking, or acting in an imaginative way that may be characterized by innovation, divergent thinking, and intellectual risk taking.

GLOBAL LEARNING – the intellectually disciplined abilities to analyze similarities and differences among cultures; evaluate natural, physical, social, cultural, historical, and economic legacies and hierarchies; and engage as community members and leaders who will continue to deal with the intricacies of an ever-changing world. Individuals should acquire the ability to analyze power; identify and critique interdependent global, regional, and local cultures and systems; and evaluate the implications for people's lives.

SOCIAL RESPONSIBILITY AND ETHICAL REASONING – the ability to assess one's own values within the social context of problems, recognize ethical issues in a variety of settings, describe how different perspectives might be applied to ethical dilemmas, and consider the ramifications of alternative actions. Individuals should acquire the self-knowledge and leadership skills needed to play a role in creating and maintaining healthy, civil, safe, and thriving communities.

What component(s) of the course will help students achieve the General Education Learning Objectives covered in the course? Provide evidence that students in the course have adequate opportunities to achieve the identified learning objectives.

Each of these objectives is met by almost all the material in the course. As an integrative studies course, the course regularly moves back and forth between scientific (GN) and humanistic (GH) perspectives on a variety of issues, and shows students how those perspectives differ, relate to one another, affect one another historically, and so on. We illustrate the history of critical and analytic thinking by showing students how scientific and humanistic thought is made; we encourage students to practice these skills through numerical exercises in homeworks and exams, team projects, and team problem-solving exercises executed during exams. As for key literacies: the fact that the course is integrative means that students will be made aware over and over of the very idea of literacy as the mastery of a different field; one of our major goals is to get students to think hard about the differences between GN literacy and GH literacy, but also to show them how both can be brought together in the service of a more general literacy about the world/universe and the life in it. We specifically address quantitative, historical, and textual literacies in homeworks and discussion, team projects, and team problem-solving exercises during the exams.

(We did not click Global Learning but many aspects of the course focus on the way that societies other than our own, including European societies of earlier centuries, but also societies in Babylon, Meso-America, and elsewhere, have thought about these issues.)

How will students be assessed to determine their attainment of the Learning Objective(s) of General Education covered in this course? This assessment must be included as a portion of the student's overall performance in this course.

Student assessment will take place via

1. Three major exams (in the version of the course for 100+ students, for which the sample syllabus here serves as a potential outline). In large versions of this course, instructors may choose to use team-based exams, online exams, or written exams, depending on their interests and resources. In smaller versions of the course, assessments may involve writing assignments or other projects not specifically mentioned here. As always at Penn State, time and the availability of curricular support in the form of teaching assistants will constrain these decisions.

2. In larger versions of the course, a group project, done by each team, which will be a creative or written work (we will give students three options for the assignment: creative, written: humanistic, and written: scientific), which will address the integrative portion of the Gen Ed experience, and emphasize critical/analytic thinking.

3. In larger versions of the course, Canvas-based assignments and/or graded discussions, which will emphasize basic scientific and humanistic literacy, including basic competency in describing the universe, the history of theories of the universe, and so on.

4. The planetarium/telescope assignment, which gives students a hands-on learning opportunity, and may be integrated into their group project as appropriate.

General Education Domain Criteria

General Education Designation: Inter-Domain

GH Criteria

Explain the methods of inquiry in humanities fields and describe how the contributions of these fields complement inquiry in other areas

- Demonstrate competence in critical thinking about topics and texts in the humanities through clear and well-reasoned responses
- Critically evaluate texts in the humanities— whether verbal, visual, or digital— and identify and explain moral or ethical dimensions within the disciplines of the humanities
- Demonstrate knowledge of major cultural currents, issues, and developments through time, including evidence of exposure to unfamiliar material that challenges their curiosity and stretches their intellectual range
- Become familiar with groups, individuals, ideas, or events that have influenced the experiences and values of different communities

What components of the course will help students achieve the domain criteria selected above?

Again, these requirements are met by most of the course, especially insofar as they are illuminated by the contrast with GN. We consider primary texts (philosophical and religious documents) as well as secondary material (work by people with PhDs in the humanities) as a way of showing students what humanists think like, and how to critically evaluate their materials. The course addresses major currents and issues, especially philosophically, as it addresses things like what it means to live in time, what it means to live alone, and so on.

GN Criteria

- Explain the methods of inquiry in the natural science fields and describe how the contributions of these fields complement inquiry in other areas
- Construct evidence-based explanations of natural phenomena
- Demonstrate informed understandings of scientific claims and their applications
- Evaluate the quality of the data, methods, and inferences used to generate scientific knowledge
- Identify societal or philosophical implications of discoveries in the natural sciences, as well as their potential to address contemporary problems

What components of the course will help students achieve the domain criteria selected above?

These requirements are met by most of the course, especially insofar as they are illuminated by the contrast with GH. In showcasing the history of science, cosmology, and astronomy, we encourage students to recognize modes of inquiry and to understand how contemporary claims in those fields are supported by evidence; we also show them how competing scientific claims and views are contended for, applied, and/or rejected in the process of coming to "informed understanding." The entire course is devoted, in many respects, the fifth criterion listed above.

Integrative Studies

Explain how the intellectual frameworks And methodologies of the two Knowledge Domains will be explicitly addressed in the course and practiced by the students.

The course outline in the previous section, as well as the answers to the questions above, explicitly address the ways we will cover these questions. This is not conceived as a course in which we talk about astronomy half the time, and humanities the other half, but as a course in which we are consistently moving back and forth between these fields, and in which our approach to science is informed by literature, history, and philosophy, and our approach to the humanities is informed by astronomy, physics, and cosmology.

To be more specific: the course has three units. The first unit focuses mainly on questions involving the history (GH) of cosmology (GN) and the relation between religion (GH) and cosmology (GN). The second unit focuses mainly on questions involving the history (GH) of physics (GN) and the relation between philosophy (GH) and physics (GN) of time. The third unit focuses mainly on questions involving aesthetic imagination (GH) about life in the universe (GN) as well as philosophical (GH) questions about human existence considered within the frame of a thermodynamically entropic universe (GN).

Demonstrate that each Of the two domains will receive approximately equal attention, providing evidence from course topics, assignments, or other course components, and that students will integrate material from both domains.

Please see the course syllabus/outline, which demonstrates quite clearly how this will be the case.

Briefly explain the staffing plan. Given that each Inter-Domain course is approved for two Knowledge Domains, it will be taught by an instructor (or instructional team) with appropriate expertise in both domains.

In its first iterations, assuming the availability of departmental and university support for team-teaching, the course will be team-taught by one instructor with expertise in astronomy (Fox, in this case) and another with expertise in the humanities (Hayot, in this case). In the future, once Fox and Hayot have co-taught the course several times, they can both imagine teaching it alone. It may also be the case that other instructors could teach it alone from the get-go, or that they would team-teach with one another (or with Fox or Hayot) and then move on to teaching it solo.

Describe the assessments that will be used to determine students' ability to apply integrative thinking.

Please see the earlier description of assessments, as they apply also to this question.

General Education Designation Requirements

Bachelor Of Arts Requirements:

- BA: Natural Sciences
- BA: Other Cultures
- BA: Foreign/World Lang (12th Unit)

- BA: Humanities
- BA: Social and BA: Behavioral Sciences
- BA: Arts
- BA: Quantification
- BA: Foreign/World Lang (All)

n/a

Campuses That Have Offered () Over The Past 4 Years

semester	AB	AL	BK	BR	BW	CR	DS	ER	FE	GA	GV	HB	HN	HY	LV	MA	NK	PC	SH	SL	UP	WB	WC	WS	XC	XP	XS	YK
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Being in the Universe (GN+GH, 3 credits)

ASTRO 019n / CMLIT 019n

Instructors: Derek Fox (dbf11) + Eric Hayot (euh2)

Being in the Universe will consider **three fundamental questions** of human existence from both **humanistic** and **scientific** perspectives:

1. What is the nature of our physical universe, and to what extent are creatures like humans a natural and predictable consequence of it?
2. What is the nature of time, and what does it mean to be a conscious being living a finite life through time?
3. What would it mean for humans to be alone in the galaxy or universe, or alternatively, not alone?

Instruction will include class lectures, in-class exercises, and online discussions, supplemented by other media, as appropriate. Assessments will include online homeworks, team projects, and in-class exams with integrated team-based exercises. *Being in the Universe* is an integrative GN+GH GenEd course.

Course Goal

The goal of *Being in the Universe* is to explore our modern understanding of **humanity's place** in a large yet finite universe as both nouns (**human beings** in a universe) and verbs (humans **being** in a universe). The course's three organizing themes will be explored from **both humanistic and scientific** perspectives: You will learn **what is known** about each subject and **how we came by** this knowledge, while developing the tools required to **analyze it, consider and debate** its consequences, and **apply it** within your own life.

Course Grading

20%	Participation (+up to 25%)
20%	5 of 6 Homeworks (drop 1)
20%	Team Project
20%	2 Midterm Exams
20%	Final Exam

A-, A	85-90%, 90-100%
B-, B, B+	70-75%, 75-80%, 80-85%
C, C+	60-65%, 65-70%
D	50-60%
F	<50%

The course curve has been specified on Canvas and should be reflected in the letter grades for each exam and assignment. Note, however, that due to course

grading rules (mainly regarding dropped scores, participation points, and extra credit), Canvas final grade estimates will only be approximate until near the end of the semester. If you have any questions about your grade please email, see one of the instructors during office hours, or make an appointment.

Course Components

Participation: Asking or answering substantive questions or otherwise participating in person during class lectures, completing the telescope observing or planetarium exercises, participating in **Canvas class discussion forums**, and contributing to the [Class Review Wiki](#) will lead to participation points. Additional participation points will be awarded for engaging in other activities throughout the semester, as discussed in class. Full credit will be defined as four substantive classroom interactions, two interactions per discussion forum, and providing full and correct responses to five Wiki questions, with additional points serving as extra credit, up to a maximum of 25% (+5% extra credit). A complete and current listing of all projects / interactions eligible for participation points will be maintained on Canvas.

Homeworks: There will be online homeworks, delivered and submitted via Canvas, every other week or so, corresponding to an expected total of six homeworks. The homework with the lowest score will be dropped. Homework assignments will be due a week (or slightly longer) after they are made available on Canvas. **You are encouraged to work in groups and discuss questions with your classmates and the TAs.** Make sure to “submit” your homework at least once before the deadline, as Canvas grades homeworks automatically. You can resubmit answers up to three times, and will receive your highest achieved grade from your three submissions. Canvas homework solutions will become available to all students after the submission deadline; hence no extensions or make-ups for homeworks can be given.

Team Project: The projects offer an opportunity for each team to **engage one of the key topics** of the course in depth, distilling their reactions and/or insights into **a single resulting work**, either written (a historical, literary, or humanistic- or scientific-analytical paper) or multimedia (a slide or video presentation). Project due dates will be distributed throughout the semester. Teams that produce projects of superior quality will be invited to present their projects to the class for extra credit.

Exams: There will be two in-class midterm exams during the semester, over the days of **Feb 25+26** and **Mar 30+31**, respectively. Owing to the team exer-

cise components of the midterms and final, there will be no make-up exams given except for serious medical or family emergencies or legitimate (unavoidable) conflicts related to University business. Such unavoidable conflicts should be reported to the instructors at the earliest possible opportunity. *In particular, team or club trips that conflict with scheduled class exams must be reported within the first two weeks of term to be eligible for make-up.* Make-up exams will be administered differently and have different content than in-class exams.

Final Exam: The comprehensive final exam is mandatory. The date and time of the final will be announced as soon as it is scheduled (it will be some time during finals week). As per University policy there will be no make-ups for the final exam except for serious, documented, medical or family emergencies.

Keys to Success

1. Prepare for class by completing the designated readings for each lecture, reviewing the posted lecture slides, and **printing the slides out** so that you can take notes on them during lecture.

2. Attend class. The online slides consist mostly of illustrations and pictures, with a limited amount of text to explain their meaning. The lectures provide much more content; since the exams are based on the lecture content and course readings, the slides alone will not substitute for attending class. The textbook and course packet allow you to prepare for each lecture in advance, and will back up your lecture notes as useful reference and review tools.

3. Ask questions - either during class, during office hours, or via email. *In addition to instructors and class TAs, you can ask any Astro 1 TA for help in Davey 442 during their scheduled office hours, as follows: Mon 1pm-6pm, Tue 1pm-6pm, Wed 1pm-3pm, Thu 11:30am-6pm, Fri 12pm-1:30pm.*

4. Work diligently on every homework to get high scores to bolster your overall grade (recommended goal: 90% or above). You are encouraged to work with your classmates and consult with the TAs and instructor if you have any difficulties. And don't forget, you have three submission attempts! Apart from contributing directly to your course grade, careful completion of each assignment serves as excellent preparation for the exams.

5. Start early on your Team Project, meeting regularly with your team so as to efficiently combine your energies and talents, together producing a superior project paper, multimedia, or video presentation.

6. Prepare for your exams by practicing the review questions on your own and with teammates, revisiting all questions from the class homeworks and worksheets, and reviewing relevant material from your lecture notes, the course readings, lecture slides, and course textbook. The Class Review Wiki has been prepared to assist you in this process – you are encouraged to review the Wiki questions with friends and teammates in advance of exams, as this can be especially efficient and helpful. Consult with your teammates to develop strategies for tackling the exam’s team-based exercise. Finally, make sure you get a good night’s sleep the night before.

7. Participate fully and energetically in the required and optional elements of the [class participation grade](#), which has the potential to improve your final grade by a full step.

Participation and Engagement

Educational research has shown that you can only learn a limited amount from lectures alone, no matter how clear or entertaining. Students learn much more from being actively engaged and grappling with the material while learning. Therefore, **active participation and collaboration is an integral part of your learning in this course**, and will be graded. Participation includes (a) in-class activities and worksheets, (b) responding aloud in class when your name is drawn and called (typically after deliberation with your teammates and neighbors, so you are actually speaking for several people around you), (c) discussing your answers with the students sitting around you when asked, and (d) posting regularly to the online discussion boards on Canvas with your classmates. In addition to helping you learn, participation activities provide vital feedback to the instructor about the progress of the class so that instruction can be adjusted accordingly. **If you are sick and have to miss class once or twice, don’t panic** - every class discussion forum and review wiki question offers the opportunity for you to make up the participation points.

On Class Etiquette

In order to maintain an orderly class environment that is respectful to all and conducive to learning, especially in a large lecture classroom, all students need to act with extra consideration. By remaining enrolled in the class, you agree to abide by the [Class Etiquette Policy](#) as articulated on Canvas. Please read this policy carefully and contact the instructors if you have any questions.

On Course Accommodations

Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. The Student Disability Resources (SDR) website provides [contact information for every Penn State campus](#). For further information, please visit the [Student Disability Resources website](#) at <http://equity.psu.edu/sdr/>.

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and [provide documentation](#). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

On Counseling and Psychological Services

Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional well-being. The University offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

[Counseling and Psychological Services at University Park \(CAPS\):](#)

<http://studentaffairs.psu.edu/counseling/> or 814-863-0395

[Counseling and Psychological Services at Commonwealth Campuses:](#)

<http://senate.psu.edu/faculty/counseling-services-at-commonwealth-campuses/>

Penn State Crisis Line (24 hours/7 days/week): 877-229-6400 or text LIONS to 741741

On Fostering a Diverse and Inclusive Environment

Penn State takes great pride in fostering a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, or harass-

ment due to age, ancestry, color, disability, gender, gender identity, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity via the [Report Bias webpage](http://equity.psu.edu/reportbias/): <http://equity.psu.edu/reportbias/>.

Academic Integrity

This class will adhere to the [Academic Integrity Policy](#) of the Department of Astronomy & Astrophysics. Please review this policy personally and contact the instructors if you have any questions.

As part of *Being in the Universe*, you are encouraged to interact and discuss ideas with other students in the class, which means you can (and should!) talk about course concepts with other students and help each other learn. Academic dishonesty is a totally distinct concept, and includes but is not limited to: cheating, plagiarizing from *any* source (including websites), lying to the professor in any way, falsifying an excuse for missed work, copying the work of another student, giving or receiving answers from any other individual for homework, exams, projects, or activities, receiving participation points when not present and participating in class, posing as or submitting answers on behalf of another individual, fabricating information or citations, having unauthorized possession of exam questions, giving or receiving information about exam questions in advance of taking an exam, using unauthorized aids during an exam, submitting work of another person, submitting your own work that was previously used without requesting permission from the instructor, tampering with the academic work of other students, or facilitating acts of academic dishonesty by others.

Any action whereby a student fails to do all the assigned work on their own, relying instead on the work of others or on unauthorized sources of information, is considered cheating. Written work that you submit for this class may be analyzed with plagiarism detection software, so be sure that any writing you do for this course, no matter how short or long, is in your own words. Any instances of academic dishonesty will be pursued under University and Eberly College of Science / College of Liberal Arts regulations concerning academic integrity. In this class there will be no warnings, even on a first offense. Academic dishonesty can result in assignment of “F” by the course instructors or “XF” by Judicial Affairs as the final grade for students judged guilty. So please – for your sake and ours – don’t cheat.

Course Outline

Unit 1: Being in a Universe

- Week 1: Cosmology as a Human Enterprise – the human quest to understand and explain the world around us, across cultures and through time
- Week 2: A Big Bang Universe – the historical development of the Big Bang model, its key evidences, and primary implications
- Week 3: The Past and Future of our Universe – placing *Earth, today* in its full spatial and temporal context
- Week 4: Beyond the Big Bang – reactions to the Big Bang model, reflections on its successes and shortcomings, and its most likely extensions
- Week 5: Project presentations, unit review, and Exam 1

Unit 2: Being in Time

- Week 6: Time as Change – reconciling time as a dimension with time as change, including a quick trip back to the birth of the universe
- Week 7: Time and Spacetime – the meaning and consequences of “spacetime” in Einstein’s special and general theories of relativity
- Week 8: Philosophies of Spacetime – reactions to and reflections on the nature of spacetime in a four-dimensional Big Bang universe
- Week 9: Visions of Time – reflecting on the human experience of time and how it connects to time as an (astro)physical quantity
- Week 10: Project presentations, unit review, and Exam 2

Unit 3: Being Alive

- Week 11: Life as We Know It – defining life, the history of life on Earth, and life’s manifestations, both known and hypothesized
- Week 12: Life in the Solar System – past, present, and future prospects for life on the other planets and moons of the Solar System
- Week 13: Life among the Stars – how we know about planets orbiting distant stars, and their prospects for supporting life
- Week 14: Alone in the Anthropocene – reflecting on the “great silence” among the stars, and possible futures for our civilization and life on Earth
- Week 15: Project presentations and class review

Final Exam

General Education Learning Objectives

Students can expect the course to alternate regularly between the scientific (GN) and humanistic (GH) approaches to each of the course's major questions and corresponding topics. In the process, students will learn how the scientific and humanistic perspectives differ, relate to one another, affect each other historically, provide new insights, and stimulate novel lines of inquiry in a cross-disciplinary sense. We will illustrate the history of critical and analytic thinking by showing students how scientific and humanistic thought is made; we will encourage students to practice these skills through numerical exercises in class activities, homeworks, and exams; and we will require students to engage in inter-domain problem-solving exercises as they complete collaborative projects and solve team problem-solving exercises during exams.

KEY LITERACIES – the ability to identify, interpret, create, communicate and compute using materials in a variety of media and contexts. Literacy acquired in multiple areas, such as textual, quantitative, information/technology, health, intercultural, historical, aesthetic, linguistic (world languages), and scientific, enables individuals to achieve their goals, to develop their knowledge and potential, to lead healthy and productive lives, and to participate fully in their community and wider society.

Key Literacies — As an inter-domain course, “Being in the Universe” aims to develop key literacies of the scientific (GN) and humanistic (GH) domains in its students. These literacies will be developed side-by-side as we work through the material of each unit, emphasizing the distinct and complementary insights that these two domains bring to our understanding of the universe around us and the challenges of being(s) within it. Key scientific literacies that will be developed include: Confronting theoretical models with observational data; applying aesthetic criteria (chiefly elegance or parsimony) to evaluation of alternative models; designing and realizing clean observational tests of hypotheses; correctly interpreting graphical presentations of data; understanding presentations of data with associated uncertainties; carrying out “order of magnitude” calculations using scientific notation; and correctly interpreting and predicting changes in systems under various scaling relations. Key humanistic literacies that will be developed include: Grappling with the cultural context(s) of scientific knowledge and scientific advances, including our modern understanding of the physical universe; interpreting historical texts and creative works in their personal and multicultural contexts; realizing new creative works that address enduring questions of existence; and developing a personal aesthetic that will support their critical engagement with important literary and imaginative works.

CRITICAL AND ANALYTICAL THINKING – the habit of mind characterized by comprehensive exploration of issues, ideas, artifacts, and events before accepting or formulating a conclusion. It is the intellectually disciplined process of conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action.

Critical and Analytical Thinking — In their scientific approaches to a topic, students will develop their ability to carry out quantitative calculations addressing questions of scale within the universe; to use scaling relations to predict the behavior of physical systems under changes in conditions; to apply data-driven / quantitative and aesthetic / qualitative approaches to their critical evaluation of alternative models; and to explain how and why the scientific consensus on each of the course's key questions was developed, or alternatively,

remains in flux. In their humanistic approaches to a topic, students will develop their ability to appreciate the diverse perspectives brought by individuals of different backgrounds; to develop their ability to engage critically with literary and imaginative works addressing key existential questions; and to think critically and reflexively about the human condition from both personal and communal perspectives.

INTEGRATIVE THINKING – the ability to synthesize knowledge across multiple domains, modes of inquiry, historical periods, and perspectives, as well as the ability to identify linkages between existing knowledge and new information. Individuals who engage in integrative thinking are able to transfer knowledge within and beyond their current contexts.

Integrative Thinking — By applying both GH and GN critical and analytical thinking models to the three fundamental questions that are central to the course, and by engaging in homeworks, exams, and projects that integrate these approaches into problem statements, solutions, and challenges, students will practice and develop their ability to engage in deep and reflective integrative thinking.

Learning Objectives

Here we break down the class goals into specific learning objectives. For greater detail, including specific questions targeting each objective, please see the Class Review Wiki.

I. Being in a Universe

1. Cosmology as a Human Enterprise
 - Engage critically with a selection of multicultural historical cosmologies reflecting some of the diversity of human societies, past and present
 - Understand the role that cosmologies have played in (de)centering the human experience within an Earthly/Universal expanse of space and time
 - Reflect critically on our individual experiences with cosmologies
 - Be familiar with the historical context for Enlightenment-era advances in the scientific understanding of the Earth, Moon, Sun, and Solar System
 - Be familiar with key historical developments leading to the modern scientific cosmology and its hierarchical structure, Earth < Solar System < Milky Way Galaxy < Universe (< Multiverse)
 - Engage critically and debate, as “insiders” and “outsiders,” key elements of the modern scientific cosmology
2. A Big Bang Universe
 - Understand the key problems with finite and static models of the universe
 - Understand the key problems with infinite and static models of the universe
 - Understand the problems with Einstein’s use of a “cosmological constant” to support his finite, static model of the universe
 - Be familiar with the observed “Hubble flow” of galaxies as evidence for an expanding universe, and the implications for the past and future of the universe
 - Understand how observations of the abundances of hydrogen, helium, and other light elements provide evidence for a Big Bang origin of the universe

- Understand how observations of very distant galaxies provide evidence for a Big Bang origin of the universe
 - Understand how observations of the cosmic microwave background radiation provide evidence for a Big Bang origin of the universe
 - Be familiar with the three most prominent features seen in all-sky maps of the cosmic microwave background radiation
3. The Past and Future of Our Universe
- Be aware that galaxies cluster together in groups and clusters
 - Be familiar with the primary constituents of a galaxy cluster, and their relative masses
 - Understand how optical, X-ray, and gravitational lensing measurements provide evidence of dark matter in galaxy clusters
 - Understand how galaxy rotation curves provide evidence of dark matter in individual galaxies
 - Understand why astronomers' evidence for dark matter is considered exciting news for particle physicists and laboratory (condensed matter) physicists
 - Understand how observations of distant supernovae allowed astronomers to discover Dark Energy
 - Understand the contrasting effects of (ordinary and dark) matter and Dark Energy on the expansion of the universe
 - Be familiar with the present mass-energy budget of the universe as it is divided into ordinary matter, dark matter, and Dark Energy
 - Be familiar with current theoretical expectations for the long-term future of the Sun and Earth, the Milky Way, and the universe at large
 - Reflect on key existential questions in the context of a large yet ultimately finite universe
4. Beyond the Big Bang
- Understand how the theory of cosmic inflation resolves important inconsistencies in the Big Bang model
 - Be familiar with key pieces of astronomical evidence in favor of cosmic inflation models
 - Be familiar with the idea, inspired by cosmic inflation theories, that our universe may be one of many in a larger "multiverse"
 - Understand how the Anthropic Principle can help us understand the properties of Earth in a modern scientific cosmology
 - Understand how the Anthropic Principle might be applied to understand the properties of the universe at large, in multiverse cosmologies
 - Debate whether multiverse theories are properly considered part of the scientific enterprise
 - Explore and confront selected literary and imaginative visions of the multiverse

II. Being in Time

6. Time as Change
- Understand the nature of time as a physical dimension (the dimension measured with clocks)

- Understand the alternative vision of “time as change,” and why it conflicts with the vision of time as a dimension
 - Be able to provide examples of reversible and irreversible (thermodynamic) systems
 - Be familiar with the key insights of Boltzmann that first reconciled these two visions of time, and under what circumstances they apply
 - Understand why we experience “time as change” during the present epoch of our universe
 - Understand how Boltzmann’s Past Hypothesis is validated by observations of the cosmic microwave background radiation
 - Understand how the approach of the universe to thermal equilibrium will eventually bring an end to the arrow of time and “time as change”
 - Engage with critical and imaginative explorations of “the end of time”
7. Time and Spacetime
- Be familiar with how metrics of space and time are distorted for observers in fast relative motion
 - Understand that the relativity of space and time implies the relativity of simultaneity, breaking the Newtonian vision of absolute universal time
 - Understand the meaning of Einstein’s equivalence principle in the context of General Relativity
 - Be familiar with how metrics of space and time are distorted for observers experiencing differential acceleration, or differing gravitational fields
 - Understand the General Relativistic picture of gravity: “matter tells spacetime how to curve; spacetime curvature tells matter how to move”
 - Understand gravitational tidal forces as a consequence of spacetime curvature
 - Be familiar with a basic picture of black holes as “massive objects with event horizons”
 - Be familiar with a basic picture of wormholes as “shortcuts” through spacetime
 - Be familiar with a basic picture of faster-than-light travel via “warp drives”
 - Understand how time travel might be possible if wormholes or warp drives can exist in our universe
8. Philosophies of Spacetime
- Be familiar with the ontologies of selected philosophies of time including Presentism, Eternalism, and the “Growing Block Time” universe
 - Understand how the relativity of simultaneity was long considered to mark the death of Presentism
 - Engage critically with the contemporary philosophical debate over the nature of time
9. Visions of Time
- Be familiar with key psychological effects that impact the human experience of time
 - Engage critically with selected literary and imaginative visions of the human experience of time
 - Reflect critically on our individual experiences of time
 - Engage critically with selected literary and imaginative visions of time travel, time dilation, and suspended animation

- Engage critically and debate the alternative “single timeline” and “forking paths” visions for the temporal evolution of the universe

III. Being Alive

11. Life as We Know It

- Debate several possible definitions of life, exploring their advantages, shortcomings, and exceptions
- Develop a basic knowledge of the history of Earth’s habitability
- Develop a basic knowledge of the history of life on Earth
- Understand the nature and meaning of the inferred existence of a “last universal common ancestor” to all life on Earth
- Understand, in general terms, the fundamental versus contingent properties of life as we know it on Earth
- Be aware of the many harsh environments observed to sustain life on Earth
- Be familiar with the fundamental requirements for life, as we understand it, to exist on other worlds

12. Life in the Solar System

- Develop a basic knowledge of the history of Venus’ habitability and the prospects for life on Venus in its distant past
- Develop a basic knowledge of the history of Mars’ habitability
- Understand, in general terms, the prospects for life on Mars, both today and in its distant past
- Understand, in general terms, the prospects for life today on Europa, Enceladus, and other icy moons of Jupiter and Saturn
- Understand, in general terms, the prospects for life today on Titan
- Be familiar with the challenges involved in robotic and human exploration of Mars, Titan, and the icy moons of Jupiter and Saturn

13. Life among the Stars

- Be familiar with the properties of stars that make them suitable or unsuitable for hosting life-bearing worlds
- Be aware of the primary factors that make a planet habitable or uninhabitable
- Understand the several means by which astronomers are able to discover planets in orbit around other stars, with their various strengths and shortcomings
- Be familiar with the current state of knowledge regarding “habitable zone” planets around other stars in our Galaxy
- Understand how astronomers plan to search for evidence of life on planets in orbit around other stars
- Be capable of discussing the terms of the Drake Equation for estimating the number of communicating civilizations in the Milky Way galaxy
- Understand the motivation for and primary techniques used to search for signs of alien civilizations in the Galaxy
- Understand the nature of the “Fermi Paradox” and its implications for the search for alien civilizations in the Galaxy
- Be familiar with key proposed resolutions of the Fermi Paradox

- Be familiar with the challenges involved in robotic and human exploration of other star systems
 - Engage critically with modern debates as to the long-term future of human civilization and artificial intelligence
14. Alone in the Anthropocene
- Engage critically with visions of monstrous and god-like (non-human) beings from selected literary traditions
 - Engage critically with literary and imaginative visions of alien civilizations, alien intelligence, and artificial intelligence
 - Be familiar with key ways in which human civilization has altered the geology, geography, and biosphere of Earth
 - Debate the various likely futures for human civilization and Earth life
 - Reflect critically on the meaning of a human life, and human civilization, within its larger cosmic context