Term Information

Effective Term	Spring 2024
Previous Value	*Autumn 2021*

Course Change Information

What change is being proposed? (If more than one, what changes are being proposed?)

Have course count as a Origins & Evolution Theme course under new GE.

What is the rationale for the proposed change(s)?

Topic lends itself very well to this new Theme.

What are the programmatic implications of the proposed change(s)?

(e.g. program requirements to be added or removed, changes to be made in available resources, effect on other programs that use the course)?

None.

Is approval of the requrest contingent upon the approval of other course or curricular program request? No

Is this a request to withdraw the course? No

General Information

Course Bulletin Listing/Subject Area	Earth Sciences
Fiscal Unit/Academic Org	School of Earth Sciences - D0656
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	2205
Course Title	The Planets
Transcript Abbreviation	Planets
Course Description	Survey of the origin and evolution of our Universe, Solar System, Planets and moons with focus on surface environments, dynamics, and the ability to host life. Add EarthSc 1200 for Physical Science GE lab credit.
Previous Value	*Survey of the solar system's planets and moons with focus on surface environments, dynamics, and the ability to host life. Autumn 2021 and after: Add EarthSc 1200 for Physical Science GE lab credit.*
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week
Flexibly Scheduled Course	Sometimes
Does any section of this course have a distance education component?	Yes
Is any section of the course offered	100% at a distance
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster

Previous Value	*Columbus, Lima, Mansfield, Marion, Newark*

Prerequisites and Exclusions

Prerequisites/Corequisites	
Exclusions	
Electronically Enforced	No

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code	40.0699
Subsidy Level	Baccalaureate Course
Intended Rank	Freshman, Sophomore, Junior, Senior

Requirement/Elective Designation

General Education course:
Physical Science; Origins and Evolution
The course is an elective (for this or other units) or is a service course for other units

Previous Value

General Education course:
Physical Science
The course is an elective (for this or other units) or is a service course for other units

Course Details

Course goals or learning objectives/outcomes

- Origins & Evolution GOAL 1: Successful students will appreciate the time depth of the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.
- Origins & Evolution GOAL 2: Successful students will understand the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.
- Illustrate their knowledge of the time depth of the universe, physical systems, life on earth, humanity or human culture by providing examples or models.
- Engage with current controversies and problems related to origins and evolution questions.
- Describe their knowledge of how the universe, physical systems, life on Earth, humanity or human culture have evolved over time.
- Explain scientific methods used to reconstruct the history of the universe, physical systems, life on earth, humanity or human culture and specify their domains of validity.
- Summarize current theories of the origins and evolution of the universe, physical systems, life on earth, humanity or human culture.

Previous Value

- *students will*

  • develop an intuition for the vast spatial and temporal scales in our Universe and how to make order-of-magnitude-estimates (or educated guesses) of quantities that are hard to know or remember precisely,
- *• revisit basic physics concepts related to motion, energy, and gravity; and how light and matter interact, which allows us to learn a tremendous amount of information from light,*
- *• use those concepts to understand planetary geology and atmospheres,*
- *visit each planet in the solar system, as well as many moons, asteroids, and comets, and learn how they are similar or different in terms of their interiors, surfaces, and atmospheres, including some that may well harbor conditions for life*
- *• be provided with an up-to-date overview of the evermore daring exploration of our solar system by space crafts.*

Content Topic List

- Solar system formation
- Age of the Earth and solar system
- The Copernican Revolution, Kepler, Brahe, and Galileo.

  The Scientific Method & Astrology
- Concepts from Physics Required to Understand Planets
- Properties of Light & Matter
- Heat and energy
- Gravity
- The Formation of our Solar System
- Plate tectonics
- Conditions for life in the solar system
- Solar system exploration

  Jovian Planets and their Moons
- Meteorite impacts
- Volcanoes and earthquakes on Earth and beyond
- Atmospheric Basics, Weather & Climate, and Earth's Atmosphere.

  Water on Earth and beyond

Previous Value

- *Solar system formation*
- *Age of the Earth and solar system*
- *Light and matter*
- *Heat and energy*
- *Gravity*
- *Plate tectonics*
- *Conditions for life in the solar system*
- *Solar system exploration*
- *Meteorite impacts*
- *Volcanoes and earthquakes on Earth and beyond*
- *Water on Earth and beyond*

Sought Concurrence No

Attachments

- Responses to Themes Panel of the ASC Curriculum Committee_EMG.docx: response to prior submission

  (Cover Letter. Owner: Griffith,Elizabeth M)
- syllabus-EARTHSC2205-revised.docx: Revised syllabus

  (Syllabus. Owner: Griffith,Elizabeth M)
- submission-origins-evolution_EARTHSC2205.docx: submission Theme Origins & Evolution

  (Other Supporting Documentation. Owner: Griffith,Elizabeth M)

Comments

- Since this course is already approved as DL, those supporting documents were not uploaded.

  Response to previous Theme review is included with revisions. *(by Griffith,Elizabeth M on 08/03/2023 12:30 PM)*
- Please see Panel feedback email sent 12/20/2021. *(by Hilty,Michael on 12/20/2021 02:37 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Griffith,Elizabeth M	11/16/2021 11:30 AM	Submitted for Approval
Approved	Griffith,Elizabeth M	11/16/2021 11:31 AM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	12/07/2021 02:55 PM	College Approval
Revision Requested	Hilty,Michael	12/20/2021 02:37 PM	ASCCAO Approval
Submitted	Griffith,Elizabeth M	08/03/2023 12:35 PM	Submitted for Approval
Approved	Griffith,Elizabeth M	08/03/2023 12:35 PM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	08/21/2023 11:47 AM	College Approval
Pending Approval	Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	08/21/2023 11:47 AM	ASCCAO Approval

Thank you for the feedback. We took time to reconsider the best fit for this course in the New General Education Themes, and decided that it would best fit in the new Theme "Origins & Evolution". We were still able to address the concerns below, and have updated the syllabus accordingly. The significant updates in the syllabus are highlighted in red.

Responses to Themes Panel of the ASC Curriculum Committee

December 16th, 2021 review of proposal for Earth Science 2205

The Panel did not vote on the proposal as they would like the following points addressed:

- **GE Theme Sustainability:**
    - The reviewing faculty found the responses in the GE Theme submission form to be well-connected for inclusion within the GE Theme: Sustainability. However, there was little support in the course syllabus, specifically the readings, schedule and grading.

    We agree that the course is well-connected, but we have found a better fit with the new "Origins & Evolution" Theme. We hope the new Theme subcommittee will agree. We have removed the request for inclusion in "Sustainability".

    - The reviewing faculty note that the responses to the ELOs highlight social, religious, ethical and economic considerations, but it is not clear where students gain these insights based upon the course readings and topics and therefore asks for more information about these considerations be included within the course syllabus. → *Not applicable*

    - The reviewing faculty are unsure if the weekly assignments pertain to the group project or if they are related to anything else within the course syllabus. To this end, they ask for clarification regarding the weekly assignments, and further elaboration on how the weekly assignments will connect to the GE Theme: Sustainability ELOs.

    We have added information in the syllabus to clarify this point. "Each week's assignments include 1) a quick participation quiz of a few questions, 2) another short quiz that covers the reading material for that week, and 3) a sub-task of your semester-long group project (referred to as Assignments 1-11 in the schedule below and described in more detail on Carmen)." *So the weekly assignments are sub-tasks for the semester-long group project and are described in more detail on Carmen. Ultimately, they relate to the Theme ELOs through the group project as described in the application submission form.*

    - The reviewing faculty ask that Sustainability be included within the course description. → *Not applicable*

    - The reviewing faculty ask for further information on the course readings as they are unclear how these will satisfy the general GE ELOs. The readings, as given, appear to be giving a purely planetary approach and not incorporating Sustainability or Lived Environments. Are there supplemental materials, such as lectures or other readings?

All the information is now updated in the syllabus and incorporates the Origins & Evolution Theme.

- Additionally, the reviewing faculty ask for clarification on the course textbook, as it is currently recommended, and students are able to purchase any edition. Will there be required course readings from the recommended textbook? Where do the course readings come from?

*It is now clear in the syllabus, p. 18 that "*The weekly Carmen modules contain self-contained reading materials with embedded pop-up questions, but each module also indicates the corresponding pages in the (optional) textbook *The Cosmic Perspective: The Solar System* for additional context. Additional primary literature such as recent news (e.g., NASA) and journal articles (e.g., *Nature*) are updated annually on Carmen with some examples included in the schedule below."

- The reviewing faculty ask for more indication in the proposal how this course will be an advanced course on the topic and within the Sustainability and Lived Environments Themes.

We feel the revised syllabus reflects this (and the responses in the submission) as the course content and assignments/assessments are built to not just test recall of information related to the Themes, but has the students build new knowledge and apply this to interesting questions related to Origins & Evolution. We have also added a note to the students in the syllabus:

This class is considered an upper-level course in which you are not only expected to remember and understand reading materials, but -critically- combine and *apply* basic concepts, such as Newton's laws and ideas from quantum mechanics to new problems; from the orbital mechanics of planets to the driving forces of planetary geology and how our atmosphere works (both naturally, and in the presence of human activities). In your group project, in particular, you will furthermore *create*, *evaluate*, and *analyze* your own proposal for an extraterrestrial human colony, i.e., constructing an entirely new sustainable environment from scratch, by building on the ELOs of the reading materials and visual aids on Carmen.

- **GE Theme Lived Environments:**
    - The reviewing faculty agree with the Sustainability TAG in that the GE Theme submission form is well-connected but does not translate to the course syllabus.

We agree that the course is well-connected, but we have found a better fit with the new "Origins & Evolution" Theme. We hope the new Theme subcommittee will agree. We have removed the request for inclusion in "Lived Environments".

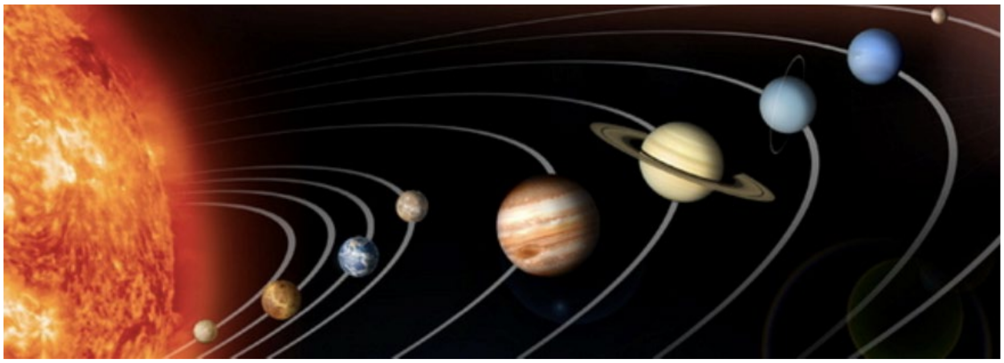
- The reviewing faculty request further elaboration of the weekly assignments and how they connect to the GE Theme: Lived Environments ELOs and tie these assignments directly to the description given on the GE Theme submission form. → *Not applicable*

- The reviewing faculty ask that more information surrounding how the GE Theme: Lived Environments ELOs will be satisfied in the course syllabus by translating the information in the GE submission form into the course topics, readings and assignments. → *Not applicable*

- The reviewing faculty ask for further information on the course readings as they are unclear how these will satisfy the general GE ELOs. The readings, as given, appear to be giving a purely planetary approach and not incorporating Sustainability or Lived Environments. Are there supplemental materials, such as lectures or other readings? → *See response above*

    - Additionally, the reviewing faculty ask for clarification on the course textbook, as it is currently recommended, and students are able to purchase any edition. Will there be required course readings from the recommended textbook? Where do the course readings come from? → *See response above*

- The reviewing faculty ask for more indication in the proposal how this course will be an advanced course on the topic and within the Sustainability and Lived Environments Themes. → *See response above*



The Planets Syllabus

EARTHSC 2205 Spring 2024 - Online

Course Information

- **Course times and location:** No scheduled meetings; all instruction occurs asynchronously on Carmen each week
- **Credit hours:** 3
- **Mode of delivery:** Distance Learning

Instructor

- **Name:** Prof. Joachim Moortgat
- **Email:** Moortgat.1@osu.edu
- **Phone number:** 614-688-2410
- **Office hours:** By appointment on http://carmenzoom.osu.edu/moortgat-office-hour

Course Description

Survey of the origin and evolution of our Universe, Solar System, Planets and moons with focus on surface environments, dynamics, and the ability to host Life. Add EarthSc 1200 for Physical Science GE lab credit. Add EarthSc 1200 for Physical Science GE lab credit.

Commented [EG1]: wants to add "sustainability" in course description for catalog

This course fulfills a 3-credit course in the **Origins & Evolution Theme** of the New General Education (GEN) curriculum, and for students on the Legacy GE (GEL) this course is a GE **Natural Science: Physical Science** 3-credit course (i.e., without a lab). *Goals and expected learning outcomes with rationale are included in this syllabus starting on page 2.*

In this course we will explore our Solar System, study the origin and evolution of (regular, dwarf-, and exo-) planets, asteroids, moons, and asteroids within it so that we may better understand our place in the Universe, the prospect of life elsewhere, and the destiny of humanity on Earth and in space. The goal of this course is to understand the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world. These topics will be developed at an advanced level that synthesizes content from Foundations courses, e.g., using various physics principles to understand how planetary geology and atmospheres work, as well as interplanetary travel. In a semester-long project, small groups of students will develop a plan for a first human colony on another planet, moon, asteroid, or comet, incorporating knowledge acquired in this course, while also integrating your personal perspectives from your major in, e.g., arts, engineering, history, psychology, education, etc.

Course Learning Outcomes

For students in the new general education (GEN) curriculum, this course is designed to satisfy the Goals and Educational Learning Objectives (ELOs) of the Origins & Evolution Theme.

The following identifies how this course addresses the general Expected Learning Outcomes (ELOs) of any Theme course in the GE, as well as the specific ELOs of the Origins and Evolution Theme.

GE Theme Goals and Expected Learning Outcomes:

As part of the **Origins & Evolution** Theme of the New General Education (GEN) curriculum, this course is designed to prepare students to be able to do the following:

General Theme GOAL 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations.

ELO 1.1 Engage in critical and logical thinking (about the topic or idea of the theme).

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or idea of the theme.

General Theme GOAL 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

ELO 2.1 Identify, describe, and synthesize approaches or experiences (as they apply to the theme).

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.

Origins & Evolution GOAL 3: Successful students will appreciate the time depth of the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.

ELO 3.1 Illustrate their knowledge of the time depth of the universe, physical systems, life on earth, humanity or human culture by providing examples or models.

ELO 3.2 Explain scientific methods used to reconstruct the history of the universe, physical systems, life on earth, humanity or human culture and specify their domains of validity.

ELO 3.3 Engage with current controversies and problems related to origins and evolution questions.

Origins & Evolution GOAL 4: Successful students will understand the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.

ELO 4.1 Describe their knowledge of how the universe, physical systems, life on Earth, humanity or human culture have evolved over time.

ELO 4.2 Summarize current theories of the origins and evolution of the universe, physical systems, life on earth, humanity or human culture.

We will achieve these goals and associated ELOs by using critical and logical thinking while building better intuition of the vast time (and spatial) depths of the Universe and the origin and evolution of (life on) Earth. We also explore how looking into Space means looking back in Time, due to the finite speed of light, and what this means for observing, or communicating with, other planets, stars, or even remote galaxies (as well as what potential distant civilizations would see when observing planet Earth). We will learn how we can look back in time on Earth using sedimentary and fossil records, as well as ice cores that can be more than a million years old, and what we can learn from such records, ranging from extinction events, meteor impacts, plate motions, and climate change.

The semester-long group project will be an opportunity to apply what you learn in class to plan the first human settlement on an assigned extraterrestrial object – you will have to consider many challenges including, for example, 1) what trajectory would you use for your space craft to get there, 2) where would you establish your settlement, taking into account temperatures / climate / weather / resources, 3) what resources would you try to bring versus what resources might be locally available (e.g., water, minerals, oxygen), 4) what are the main environmental challenges and how might you deal with those, 5) how would you communicate with loved ones still on Earth. The exercise involves literature review, properly citing references, teamwork, constructing effective visual aids, and an oral presentation of results to your peers. This will require you to both incorporate the basic physics laws etc. taught in this and prior courses -and- bring your own background to the table in considering what social science, arts/dance, law, medical, pedagogical, engineering, etc. aspects you may want to incorporate in your plans. You will regularly meet with your team-members (through, e.g., zoom) to discuss what you have learned in the last lecture/labs and how to incorporate this into your mission plans. Plans that seemed like a good idea early in the semester may turn out to be less feasible as you learn more about interplanetary travel and the conditions on your planetary object. Creativity is paramount in succeeding in this project.

We will learn about the scientific methods used to reconstruct the history of the universe, physical systems, life on earth, humanity and specify their domains of validity: for example, we will learn about how ancient Greeks accurately estimated the Earth's circumference by measuring Sun angles from two locations at the same time, what scientific arguments were used in the Copernican revolution to go from an Earth-centered model of the University consisting of perfect spheres to our current understanding of imperfect 'lumpy' objects circling each other, both through the mathematical models by Kepler and Newton and the experiments and first telescope observations by Galileo. Using the scientific methods and principles, we will learn how our, and other planets' atmospheres work, blocking harmful radiation from the Sun, providing a greenhouse effect, forming clouds that can distribute water/rain, why the atmosphere contains a large fraction of oxygen (because of Life!), and all the necessary ingredients for the origin and evolution of Life as we know it. You will also learn how to contextualize early scientific controversies given knowledge at the time, and discuss the social, political, and religious conditions that influenced discussions regarding origins and evolution over time.

The course also has initial and final surveys, as well as questions embedded in midterms, to gauge how your opinions and understanding of critical concepts evolve over the course of the semester. Finally, the course includes weekly quizzes that provide you with regular feedback on whether or not you are effectively absorbing and applying the material and allow early intervention (e.g., an office hour to discuss study methods) when necessary.

Planetary science is a highly active field and each year there are new discoveries with surrounding controversies that we discuss, such as whether or not the latest findings on Mars prove the past existence of Life on that planet, whether we will find life on distant moons like Europa or Enceladus, whether and where we will find a Planet Nine to take Pluto's former title, and what the latest estimates are of the age of the Universe. The Carmen course has a separate module "Planets in the Press" that is updated frequently throughout the semester with more information than we can cover in depth. Throughout the semester, you will also debate the chances of (existence/meeting/communicating with) extraterrestrial life, in terms of making educated guesses of the likelihood, as well as recent developments, such as the recent UFO hearings in Congress, and a new effort at detecting extraterrestrial technology.

The evolution over time of the Universe, our Solar System, planet Earth, the origins and evolution of life on Earth (and potentially elsewhere), and the development of human culture and Science are the subject of this entire course. Your knowledge of these subjects will be assessed frequently. Each week has one check-in quiz and a subject-matter quiz. Each of the three major sections of the course ends with a midterm that covers all material in that section. And at the end of the semester each group of 5-6 students presents their proposal for a human colony on an extraterrestrial object (other planet, dwarf planet, moon, asteroid, comet), which requires you to creatively synthesize your knowledge on how the evolution of Earth made human life possible here, and how to try and replicate this elsewhere.

For students in the legacy general education (GEL) curriculum, this course is designed to satisfy the Goal and Educational Learning Objectives (ELOs) of a Natural Science: Physical Science course.

Legacy General Education (GEL)

Natural Science

GOAL: Students understand the principles, theories, and methods of modern science, the relationship between science and technology, the implications of scientific discoveries and the potential of science and technology to address problems of the contemporary world.

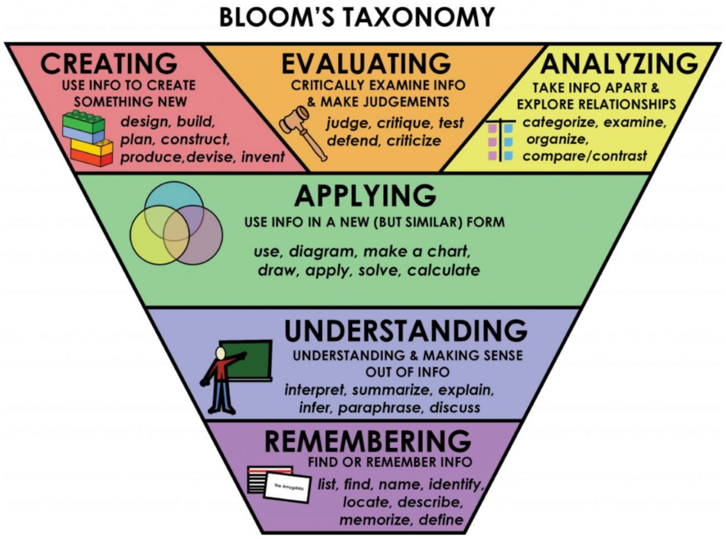
Expected Learning Outcomes

- **PHYSICAL SCIENCE**

    1. Students understand the basic facts, principles, theories and methods of modern science.
    2. Students understand key events in the development of science and recognize that science is an evolving body of knowledge.
    3. Students describe the inter-dependence of scientific and technological developments.

4. Students recognize social and philosophical implications of scientific discoveries and understand the potential of science and technology to address problems of the contemporary world.

NOTE: This class is considered an upper-level course in which you are not only expected to remember and understand reading materials, but -critically- combine and *apply* basic concepts, such as Newton's laws and ideas from quantum mechanics to new problems; from the orbital mechanics of planets to the driving forces of planetary geology and how our atmosphere works (both naturally, and in the presence of human activities). In your group project, in particular, you will furthermore *create*, *evaluate*, and *analyze* your own proposal for an extraterrestrial human colony, i.e., constructing an entirely new sustainable environment from scratch, by building on the ELOs of the reading materials and visual aids on Carmen.



This course develops higher-order thinking skills represented as the top of the Bloom's Taxonomy shown here from: https://www.thoughtco.com/blooms-taxonomy-the-incredible-teaching-tool-2081869

How This Online Course Works

Mode of delivery: This course is 100% online. There are no required sessions when you must be logged in to Carmen at a scheduled time. The online materials consist of reading, videos, practice quizzes, short assignments, and discussions boards. The course also involves a semester-long group project with instructions provided on Carmen.

Readings: Course modules on Carmen include all required reading, but students may consider acquiring (any edition of) *The Cosmic Perspective: The Solar System* Bennett, Danahue, Schneider, and Voit, Pearson Education Inc. for more background (older editions are cheaper, and there is also an electronic version). Each weekly module on Carmen provides corresponding page numbers of the book. Additional primary literature related to the course Themes is linked from Carmen as well and indicated in the Course Schedule at the end of this syllabus.

Pace of online activities: This course is divided into **weekly modules** that are released one week ahead of time. Students are expected to keep pace with weekly deadlines but may schedule their efforts freely within that time frame.

Credit hours and work expectations: This is a **3-credit-hour course**. According to Ohio State policy, students should expect around 3 hours per week of time spent on direct instruction (instructor content and Carmen activities, for example) in addition to 6 hours of homework (reading and assignment preparation, for example) to receive a grade of (C) average.

Attendance and participation requirements: Because this is an online course, your attendance is based on your online activity and participation. The following is a summary of everyone's expected participation:

- **Participating in online activities for attendance**: **AT LEAST 3x PER WEEK** You are expected to log in to the course in Carmen every week. (During most weeks you will probably log in many times.) If you have a situation that might cause you to miss an entire week of class, discuss it with your instructor *as soon as possible.*
- **Office hours and live sessions**: **OPTIONAL** All live, scheduled events for the course, including office hours, are optional.
- **Participating in discussion forums**: **2+ TIMES PER WEEK.** As part of your participation, each week you can expect to post at least twice as part of our substantive class discussion on the week's topics.
- **Group project**: you will be assigned to a group of 5 to 6 students for the duration of the semester. Together with your group, you will work on a proposal to establish the first human colony on one of the planets, moons, asteroids, or comets in our Solar System; a plan that you will present as a group at the end of the semester on CarmenZoom. Your

presentation will be graded on a rubric (on Carmen) that includes both the presentation materials (slides) and oral delivery, and how well you covered topics such as how to travel there, what resources are/aren't available, how you might resolve the lack of certain resources, what life on your object would be like (e.g., in terms of temperatures, gravity, seasons, sunlight, etc.). You will have a group section on Carmen where you should have a weekly discussion (at a time fitting your own schedules) about progress on this project, as well as help each other out with the other online materials for each week's Unit. In other words, this is a more intimate setting for discussions than the class-wide discussion forum.

Course Materials and Technologies

Textbook: Optional but Recommended

The Cosmic Perspective: The Solar System Bennett, Danahue, Schneider, and Voit, Pearson Education Inc. (any edition; cheap second-hand copies are easily found online)

Course Technology

For help with your password, university email, Carmen, or any other technology issues, questions, or requests, contact the OSU IT Service Desk. Standard support hours are available at https://ocio.osu.edu/help/hours, and support for urgent issues is available 24/7.

- **Self-Service and Chat support:** http://ocio.osu.edu/selfservice
- **Phone:** 614-688-HELP (4357)
- **Email:** 8help@osu.edu
- **TDD:** 614-688-8743

Baseline Technical Skills for ONLINE Courses

- Basic computer and web-browsing skills
- Navigating Carmen: for questions about specific functionality, see the Canvas Student Guide.

Required Technology Skills Needed for This Course

- CarmenConnect text, audio, and video chat
- Recording a slide presentation with audio narration
- Recording, editing, and uploading video

Required Equipment

- Computer: current Mac (OS X) or PC (Windows 7+) with high-speed internet connection
- Webcam: built-in or external webcam, fully installed and tested
- Microphone: built-in laptop or tablet mic or external microphone
- Other: a mobile device (smartphone or tablet) or landline to use for BuckeyePass authentication

Required Software

- None.

CARMEN Access

You will need to use BuckeyePass multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you take the following steps:

- Register multiple devices in case something happens to your primary device. Visit the BuckeyePass - Adding a Device help article for step-by-step instructions.
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click "Enter a Passcode" and then click the "Text me new codes" button that appears. This will text you ten passcodes good for 365 days that can each be used once.
- Download the Duo Mobile application to all of your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service.

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at 614-688-4357 (HELP) and the IT support staff will work out a solution with you.

Grading and Faculty Response

How Your Grade is Calculated

Assignment Category	Points
Midterm 1	25
Midterm 2	25
Midterm 3	25
Group presentation	10
Weekly assignments (10 pts) and quizzes (5 pts)	15
Engagement: up to 10 bonus points. Best group presentations (5 pts), top 10% constructive activity on discussion boards (5 pts), valuable suggestions to improve on-line materials (2.5 pts).	10
Total	100 + 10 bonus

See Course Schedule for due dates.

Late Assignments

Late submissions will not be accepted. Please refer to Carmen for due dates.

Instructor Feedback and Response Time

I am providing the following list to give you an idea of my intended availability throughout the course. (Remember that you can call **614-688-HELP** at any time if you have a technical problem.)

- **Grading and feedback:** For large weekly assignments, you can generally expect feedback within **7 days**.

- **Email:** I will reply to emails within **24 hours on days when class is in session at the university**.
- **Discussion board:** I will check and reply to messages in the discussion boards every **24 hours on school days**.

Grading Scale

93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B
80–82.9: B-
77–79.9: C+
73–76.9: C
70–72.9: C-
67–69.9: D+
60–66.9: D
Below 60: E

Other Course Policies

Discussion and Communication Guidelines

The following are my expectations for how we should communicate as a class. Above all, please remember to be respectful and thoughtful.

- **Writing style**: While there is no need to participate in class discussions as if you were writing a research paper, you should remember to write using good grammar, spelling, and punctuation. A more conversational tone is fine for non-academic topics.
- **Tone and civility**: Let's maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn't always come across online.
- **Citing your sources**: When we have academic discussions, please cite your sources to back up what you say. (For the textbook or other course materials, list at least the title and page numbers. For online sources, include a link.)
- **Backing up your work**: Consider composing your academic posts in a word processor, where you can save your work, and then copying into the Carmen discussion.

Throughout this semester, you will work in the same small group. Collaborating as a group does not come natural to everyone, in general, and working with a group of people with all different backgrounds can take even more practice. But an abundance of research has demonstrated that diverse teams are most effective. Many successful companies now try to capitalize on the full breath of their 'human capital'.

Diverse teams make strong teams. Assuming of course that

- all team members are respectful towards each other,
- one or more team members do not dominate discussions at the expense of others, and
- all team members carry their weight and contribute equally.

Diversity Statement

As your instructor in this course, I strongly support OSU's general commitment to diversity:

> "The Ohio State University affirms the importance and value of diversity in the student body. Our programs and curricula reflect our multicultural society and global economy and seek to provide opportunities for students to learn more about persons who are different from them. We are committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among each member of our community; and encourages each individual to strive to reach his or her own potential. Discrimination against any individual based upon protected status, which is defined as age, color,

disability, gender identity or expression, national origin, race, religion, sex, sexual orientation, or veteran status, is prohibited."

If you experience any lack of respect in this context either by myself or any of your fellow students, please do not hesitate to reach out to me, my TA, or a neutral party (e.g. the Office of Diversity and Inclusion: odi@osu.edu). Also, if you have a name and/or set of pronouns that differ from those apparent on Carmen, please let me know!

Academic Integrity Policy

POLICIES FOR THIS ONLINE COURSE

- **Quizzes and exams**: You must complete the midterms yourself, without any external help or communication. Weekly quizzes are intended as self-checks and can be repeated as many times as you like.
- **Reusing past work**: In general, you are prohibited in university courses from turning in work from a past class to your current class, even if you modify it. If you want to build on past research or revisit a topic you've explored in previous courses, please discuss the situation with me.
- **Falsifying research or results**: All research you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results or your library research look more successful than it was.
- **Collaboration and informal peer-review**: The course includes many opportunities for formal collaboration with your classmates. While study groups and peer-review of major written projects is encouraged, remember that comparing answers on a quiz or assignment is not permitted. If you're unsure about a particular situation, please feel free just to ask ahead of time.
- **Group projects**: This course includes a group project, which can be stressful for students when it comes to dividing work, taking credit, and receiving grades and feedback. I have attempted to make the guidelines for group work as clear as possible for each activity and assignment, but please let me know if you have any questions.

Ohio State's Academic Integrity Policy

Academic integrity is essential to maintaining an environment that fosters excellence in teaching, research, and other educational and scholarly activities. Thus, The Ohio State University and the Committee on Academic Misconduct (COAM) expect that all students have read and understand the university's Code of Student Conduct (studentconduct.osu.edu), and that all students will complete all academic and scholarly assignments with fairness and honesty. Students must recognize that failure to follow the rules and guidelines established in the university's *Code of Student Conduct* and this syllabus may constitute "Academic Misconduct."

The Ohio State University's *Code of Student Conduct* (Section 3335-23-04) defines academic misconduct as: "Any activity that tends to compromise the academic integrity of the university or subvert the educational process." Examples of academic misconduct include (but are not limited to) plagiarism, collusion (unauthorized collaboration), copying the work of another student, and possession of unauthorized materials during an examination. Ignorance of the university's *Code of Student Conduct* is never considered an excuse for academic misconduct, so I recommend that you review the *Code of Student Conduct* and, specifically, the sections dealing with academic misconduct.

If I suspect that a student has committed academic misconduct in this course, I am obligated by university rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the university's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the university.
If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

Other sources of information on academic misconduct (integrity) to which you can refer include:

- Committee on Academic Misconduct (go.osu.edu/coam)
- Ten Suggestions for Preserving Academic Integrity (go.osu.edu/ten-suggestions)
- Eight Cardinal Rules of Academic Integrity (go.osu.edu/cardinal-rules)

Copyright for Instructional Materials

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Creating an Environment Free from Harassment, Discrimination, and Sexual Misconduct

The Ohio State University is committed to building and maintaining a community to reflect diversity and to improve opportunities for all. All Buckeyes have the right to be free from harassment, discrimination, and sexual misconduct. Ohio State does not discriminate on the basis of age, ancestry, color, disability, ethnicity, gender, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, pregnancy (childbirth, false pregnancy, termination of pregnancy, or recovery therefrom), race, religion, sex, sexual orientation, or protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment. Members of the university community also have the right to be free from all forms of sexual misconduct: sexual harassment, sexual assault, relationship violence, stalking, and sexual exploitation.

To report harassment, discrimination, sexual misconduct, or retaliation and/or seek confidential and non-confidential resources and supportive measures, contact the Office of Institutional Equity:

1. Online reporting form at equity.osu.edu,
2. Call 614-247-5838 or TTY 614-688-8605,
3. Or email equity@osu.edu

The university is committed to stopping sexual misconduct, preventing its recurrence, eliminating any hostile environment, and remedying its discriminatory effects. All university employees have reporting responsibilities to the Office of Institutional Equity to ensure the university can take appropriate action:

- All university employees, except those exempted by legal privilege of confidentiality or expressly identified as a confidential reporter, have an obligation to report incidents of sexual assault immediately.
- The following employees have an obligation to report all other forms of sexual misconduct as soon as practicable but at most within five workdays of becoming aware of such information: 1. Any human resource professional (HRP); 2. Anyone who supervises faculty, staff, students, or volunteers; 3. Chair/director; and 4. Faculty member.

Your Mental Health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. No matter where you are engaged in distance learning, The Ohio State University's Student Life Counseling and Consultation Service (CCS) is here to support you. If you find yourself feeling isolated, anxious, or overwhelmed, on-demand mental health resources (go.osu.edu/ccsondemand) are available. You can reach an on-call counselor when CCS is closed at 614- 292-5766. **24-hour emergency help** is available through the National Suicide Prevention Lifeline website (suicidepreventionlifeline.org) or by calling 1-800-273-8255(TALK). The Ohio State Wellness app (go.osu.edu/wellnessapp) is also a great resource.

Other resources

For an overview and contact information regarding student academic services offered on the OSU main campus, please visit: http://advising.osu.edu/welcome.shtml

For an overview and contact information for student services offered on the OSU main campus, please visit: http://ssc.osu.edu.

Accessibility Accommodations for Students with Disabilities

Requesting Accommodations

The university strives to make all learning experiences as accessible as possible. If you anticipate or experience academic barriers based on your disability including mental health, chronic or temporary medical conditions, please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services (SLDS). After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. In light of the current pandemic, students seeking to request COVID-related accommodations may do so through the university's request process, managed by Student Life Disability Services.

Disability Services Contact Information

- Phone: 614-292-3307
- Website: slds.osu.edu
- Email: slds@osu.edu
- In person: Baker Hall 098, 113 W. 12th Avenue

Accessibility of Course Technology

This online course requires use of CarmenCanvas (Ohio State's learning management system) and other online communication and multimedia tools. If you need additional services to use these technologies, please request accommodations as early as possible.

- CarmenCanvas accessibility (go.osu.edu/canvas-accessibility)
- Streaming audio and video
- CarmenZoom accessibility (go.osu.edu/zoom-accessibility)

Course Schedule

Note: The weekly Carmen modules contain self-contained reading materials with embedded pop-up questions, but each module also indicates the corresponding pages in the (optional) textbook *The Cosmic Perspective: The Solar System* for additional context. Additional primary literature such as recent news (e.g., NASA) and journal articles (e.g., *Nature*) are updated annually on Carmen with some examples included in the schedule below.

Each week's assignments include 1) a quick participation quiz of a few questions, 2) another short quiz that covers the reading material for that week, and 3) a sub-task of your semester-long group project (referred to as Assignments 1-11 in the schedule below and described in more detail on Carmen). Midterms evaluate retention and application of the reading materials and consist of similar questions as the weekly quizzes.

Commented [EG2]: ?? can I add this??

All Assignments and Quizzes are due at the end of the week in which they are listed.

The group project involves all general and Theme-specific ELOs, as described above. Weekly readings, activities, and quizzes address multiple overlapping ELOs.

Week	Dates	Topics, Readings, Assignments, Deadlines
1		Reading: §1.1 – §1.3 (18pg) Physics Today https://doi.org/10.1063/PT.6.3.20190312a Introductions The Scale and Age of the Universe • *critical thinking about relative distances, sizes, and time-scales* • *learn about the time-depth of the Universe, our Solar System, and Life on Earth* • *learn how looking into Space is looking back in Time* • *learn about scientific methods used by ancient civilizations to measure time and large distances* • *discuss current controversies around the age of the Universe* Assignment 1 Quiz
2		Reading: §2.1 (7pg) Patterns in the Night Sky • *apply concepts from Week 1 to understand the movement of Earth relative to distant stars and closer Moons and Planets* • *use critical thinking to figure out where the Moon and each of the visible Planets are located in our local sky, even during the day* • *learn how to use the concept of angular distance to easily estimate not only the distance to the Moon and Sun but also the vertical height and distance of, e.g., buildings, trees, or mountains in your field of view* Assignment 2 Quiz
3		Reading: §2.2 – §2.4 (14pg) and https://www.britannica.com/science/calendar/Ancient-and-religious-calendar-systems Seasons, Moon Phases, Eclipses, and Retrograde Planetary Motions

		• *learn how the unique distance of Earth from our star, the Sun, and the tilt of Earth's rotation axis create an environment hospitable to Life, as well as the seasons that our interconnected food production and water resources rely on, and contrast these factors with the similar/different seasons on other Planets* • *discover how humans, interacting with their environments, have created different types of calendar systems throughout history to keep track of, e.g., optimal seeding and harvesting practices* • *use critical thinking to figure out when and where to find the Moon in our local sky* • *use critical thinking to figure out if/when the Earth and Moon travel through the same location in Space and appreciate the speeds at which Earth and other celestial objects are hurtling through Space* Assignment 3 Quiz
4		Reading: §3.2 – §3.5 (18pg) & Video "Talking to science deniers and skeptics is not hopeless" McIntyre, *Nature* **596** (2021) doi.org/10.1038/d41586-021-02152-y Lower, S. "Treating astrology's claims with all due gravity", *Nature* **447**, pg 528 (2007) The Copernican Revolution, Kepler, Brahe, and Galileo. The Scientific Method & Astrology • *learn about the development of what we now call the Scientific Method and the history of how we came to understand the origins and evolution of the Universe, our Solar System, and Earth: from the Big Bang to current times to the expected future of the Universe* • *after remembering Newton's laws of gravity, learn about the observations that could not be explained by Newton's (and Kepler's) laws and led Einstein to his theories of Special and General Relativity* • *appreciate how Newton's laws can still be used as highly accurate estimates within a certain range of validity (weak gravity), whereas even Einstein's laws break down at the smallest scales of Quantum Mechanics* • *appreciate what a 'scientific theory', such as Darwin's theory of evolution, mean and discuss controversies around evolution and other theories*

		• *discuss whether astrology is a sound scientific theory and design your own empirical experiments to test (aspects of) that theory* Assignment 4 Quiz
5		Midterm 1 (and practice session) Optional visit to OSU Department of Astronomy Planetarium for on-campus students.
6		Reading: §4.1 – §4.5 (20pg) Concepts from Physics Required to Understand Planets • *this week and the next will build a foundation of concepts that are essential in understanding how Earth and other planets 'work' and the origin of environments that are (in)hospitable to the evolution of human Life* • *understand planetary orbits and how gravitational slingshots are used by humans to most efficiently travel in interplanetary space (use this in your proposal for an extraterrestrial human colony)* • *think critically about how you might use concepts like conservation of energy and angular momentum in the design of your group's human habitat* • *learn about how tidal forces from a large planet can cause volcanoes on orbiting moons; how could you tap into that massive source of energy?* Assignment 5 Quiz
7		Reading: §5.1 – §5.4 (20pg) Properties of Light & Matter • *learn to appreciate how almost everything humans experience about their environments, from nearby objects to distant celestial bodies, is deduced from how light and matter interact* • *learn about the scientific theories and methods used in optical telescopes ('large binoculars') but also telescopes that see the Universe in, e.g., x-ray, gamma-ray, microwave, radio radiation, as well as cosmic rays and most recently in gravitational waves* • *recap of basic concepts from the theory of quantum mechanics and its range of validity*

		• *construct your own spectrometer and use it to explore the direct and reflected light around you, e.g., from the Sun, your phone or laptop, and various different types of light bulbs/sources* • *lay a foundation that will be critical in understanding how planetary atmospheres works in Week 12* Assignment 6 Quiz
8		Reading: Ch. 7 & Ch. 8 (13pg) and Hayashi, C., Nakazawa, K., & Nakagawa, Y. (1985). Formation of the solar system. Protostars and planets II, 1100-1153. https://www.nature.com/articles/d41586-021-00456-7 https://www.nytimes.com/2022/09/15/magazine/extraterrestrials-technosignatures.html The Formation of our Solar System • *synthesize concepts developed in earlier weeks to learn about the origin and evolution of our Solar system, providing the unique circumstances that led to a planet, Earth, in the Sun's 'goldilocks' zone with temperatures that allowed the formation of an atmosphere and other conditions essential to the origin and subsequent evolution of Life* • *appreciate how the interpretation and discussions of appropriate evidence led to the acceptance of one formation theory over earlier controversial alternatives* • *discuss controversies regarding some of the details of the origin and evolution of our Solar System, such as where all the water on Earth came from, and how some of the planet-moon systems formed* • *discuss how other planetary systems, now discovered at astonishing rates and totaling well over 5000, confirm and/or challenge our understanding of our own Solar System* • *think critically about whether Life on Earth was inevitable and what the chances are of the existence of Life elsewhere in the Universe, as well as how we would find out and/or communicate with extraterrestrial civilizations* Assignment 7 Quiz

9		Midterm 2 (and practice session)
10		Spring Break
11		Reading: §9.1 – §9.2 (13pg), §9.3 – §9.6 (16pg; cursory) and https://www.nationalgeographic.org/encyclopedia/petroleum/ "Diverse organic-mineral associations in Jezero crater, Mars", *Nature* **619**, pages 724–732 (2023) Planetary Geology • *build on concepts from Week 6 to learn how geological processes unique to Earth, such as plate tectonics and erosion by wind, liquid water, and ice, are critical in shaping our lived environment by, for example, providing a self-regulating 'thermostat' of global temperatures, as well as how human activities are significantly disturbing this fine-tuned balance* • *learn how geological processes have provided humanity with its main source of (fossil) energy for ~100 years, and how the use of fossil fuels has affected the Earth's Carbon Cycle* • *compare Earth's geology to that of other planets, dwarf planets, moons, and asteroids, appreciating both similarities but also surprising differences* • *discuss historic controversies around the -at the time seemingly crazy- theory of plate tectonics as well as ongoing questions of why our sister planet Venus does not have plate tectonics* • *learn about the latest updates on evidence for past water and perhaps Life on Mars* Assignment 8 Quiz
12		Reading: Ch. 10 (30pg) Atmospheric Basics, Weather & Climate, and Earth's Atmosphere. Thompson, L.G., Davis, M.E., Mosley-Thompson, E., Sowers, T.A., Henderson, K.A., Zagorodnov, V.S., Lin, P.N., Mikhalenko, V.N., Campen, R.K., Bolzan, J.F. and Cole-Dai, J., 1998. A 25,000-year tropical climate history from Bolivian ice cores. *Science*, *282*(5395), pp.1858-1864. Krug, E.C. and Frink, C.R., 1983. Acid rain on acid soil: a new perspective. *Science*, *221*(4610), pp.520-525.

		Prillaman, M., 2022. News: Scientists have unearthed what could be the world's oldest ice core. *Nature,* 609, pp. 22-23. https://www.nature.com/articles/d41586-022-02129-5 • *build on concepts from Week 7 to learn what processes led to the evolution of Earth's unique atmosphere, appreciate its fragile nature, and apply critical thinking skills to estimate for yourself how various human activities can significantly affect the sustainability of the environment that our atmosphere provides (e.g., acid rain and climate change)* • *learn how OSU researchers established a world renowned 'library' of ice cores that allows us to determine what the Earth's climate was like over tens of thousands of years* • *compare Earth's atmosphere to the vastly different current atmospheres of otherwise similar planets like Mars and Venus, and how the latter two may have evolved from conditions much more hospitable to Life* • *discuss controversies surrounding the human impact on our atmosphere, past and present, and how the discourse around such challenges has sometimes led to positive policy changes and sometimes not* • *discuss with your group what approach you will take to create a livable and sustainable atmosphere in your extraterrestrial human colony* Assignment 9 Quiz
13		Reading: Ch. 11 (25pg) Postberg, F., Sekine, Y., Klenner, F., Glein, C.R., Zou, Z., Abel, B., Furuya, K., Hillier, J.K., Khawaja, N., Kempf, S. and Noelle, L., 2023. Detection of phosphates originating from Enceladus's ocean. *Nature*, *618*(7965), pp.489-493. Jovian Planets and their Moons • *learn how, mostly in recent decades, humans have started to explore the outer reaches of our Solar System and have come to realize that perhaps some of the Jovian moons, rather than say Mars, may be the most likely nearby celestial bodies with conditions conducive to the origin and evolution of extraterrestrial Life* • *discuss with your group what it takes to maintain a sustainable environment for human (and other life forms) existence, how human actions are impacting such sustainability on Earth, and the opportunities and -mostly- challenges to appreciate when considering Life on other moons and/or planets*

		• *think critically about a communication system for humans on, say, a moon of Neptune to talk to loved ones on Earth* • *think about challenges related to, e.g., solar panels for energy in the outer reaches of our Solar Systems* Assignment 10 Quiz
14		Reading: Ch. 12 (21pg) and https://exoplanets.nasa.gov/alien-worlds/strange-new-worlds/ https://www.nationalgeographic.com/astrobiology/goldilocks-worlds/ Asteroids, Comets, Dwarf Planets, and Exoplanets • *learn about early interpretations and perceptions of comets and meteorites, e.g., as omens; rare minerals essential to our current society that may soon be harvested from asteroids; the risks of extinction events from potential giant impacts on Earth; and what earlier such extinction events teach us about the limits of sustainability of our environment for, e.g., mammals like us* • *discuss the similarities and differences between our Solar System and other planetary systems and how the latter may challenges our origin theories* • *think critically with your group members about how life on, say, an asteroid or comet compares to that one larger planets; what resources are more readily available? which ones are severely lacking? Use the physics concepts from earlier in the semester to come up with clever potential solutions.* Assignment 11 Quiz
15		Midterm 3 (and practice session)

GE Theme course submission worksheet: Origins & Evolution

Overview

Courses in the GE Themes aim to provide students with opportunities to explore big picture ideas and problems within the specific practice and expertise of a discipline or department. Although many Theme courses serve within disciplinary majors or minors, by requesting inclusion in the General Education, programs are committing to the incorporation of the goals of the focal theme and the success and participation of students from outside of their program.

Each category of the GE has specific learning goals and Expected Learning Outcomes (ELOs) that connect to the big picture goals of the program. ELOs describe the knowledge or skills students should have by the end of the course. Courses in the GE Themes must meet the ELOs common for **all** GE Themes and those specific to the Theme, in addition to any ELOs the instructor has developed specific to that course. All courses in the GE must indicate that they are part of the GE and include the Goals and ELOs of their GE category on their syllabus.

The prompts in this form elicit information about how this course meets the expectations of the GE Themes. The form will be reviewed by a group of content experts (the Theme Advisory) and by a group of curriculum experts (the Theme Panel), with the latter having responsibility for the ELOs and Goals common to all themes (those things that make a course appropriate for the GE Themes) and the former having responsibility for the ELOs and Goals specific to the topic of **this** Theme.

Briefly describe how this course connects to or exemplifies the concept of this Theme (Origins & Evolution)

In a sentence or two, explain how this class "fits' within the focal Theme. This will help reviewers understand the intended frame of reference for the course-specific activities described below.

EARTHSC 2205 "Planets" has been a key offering of the School of Earth Sciences at the 2000-level since 1990 (formerly as Geological Sciences 205, "Physical Geology of Earthlike Planets"). The course was completely revamped in 2014 and again in 2020 to broaden the scope and ELOs and modernize the course materials. It is currently offered as an on-line course with typical enrollments of > 100 students.

The course is divided into three sections. The first section considers humanity's place in the universe: our 'cosmic address', our time on the 'cosmic calendar', and how those allowed the origin and continued survival of humanity. The second section recaps critical physics concepts, from classical to quantum mechanics, necessary to understand – in the third section– how planetary orbits, geology, and atmospheres work and allow Life. The third section also explores why other similar planets like Mars and Venus have evolved to no longer support life and how past and current human activities threaten the continued survival of our and other species, e.g., as a result of climate change.

The course is offered at the 2000 level because it requires students to synthesize different physics concepts from Foundations courses, use critical thinking in performing informed back-of-the-envelope calculations, and apply those skills in a semester-long group project to propose and present a plan to establish a human colony on another planet, comet, or asteroid.

We see a clear fit with this theme which focusses on students "Having an appreciation of the deep past is important for understanding humanity's place in the universe. The origins and evolution theme puts humans into this larger context and allows us to recognize the fragility of the human condition, how and why humans have survived over time—i.e., our strength as a species-- as well as how and why other closely related human species became extinct. "

Connect this course to the Goals and ELOs shared by *all* Themes

Below are the Goals and ELOs common to all Themes. In the accompanying table, for each ELO, describe the activities (discussions, readings, lectures, assignments) that provide opportunities for students to achieve those outcomes. The answer should be concise and use language accessible to colleagues outside of the submitting department or discipline. The specifics of the activities matter—listing "readings" without a reference to the topic of those readings will not allow the reviewers to understand how the ELO will be met. However, the panel evaluating the fit of the course to the Theme will review this form in conjunction with the syllabus, so if readings, lecture/discussion topics, or other specifics are provided on the syllabus, it is not necessary to reiterate them within this form. The ELOs are expected to vary in their "coverage" in terms of number of activities or emphasis within the course. Examples from successful courses are shared on the next page.

Goal 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations. In this context, "advanced" refers to courses that are e.g., synthetic, rely on research or cutting-edge findings, or deeply engage with the subject matter, among other possibilities.

Goal 2: Successful students will integrate approaches to the theme by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

ELO 1.1 Engage in critical and logical thinking.	Critical and logical thinking is a main theme of nearly all activities in this course. As a few representative examples: • In the first week, students construct a scale model of the Solar System at the size of Columbus (similar to the smaller-sized scale model built on OSU campus), and then drawn on a physical or virtual (google) map, which is a second rescaling. This exercise requires multiple unit conversions and is intentionally prone to mistakes when students quickly enter numbers on a calculator. The objective of this exercise, and others in the course, is for students to develop an intuition for relative magnitudes (not just of celestial objects and distances, but in general problem solving), and to make educated order-of-magnitude estimates without the use of a calculator. • As part of the same exercise, students are guided to the realization that -on average- Mercury is the closest planet to -each- of the other 7 planets in the Solar System! [Because, unlike in typical illustrations, all planets are not neatly lined up but rather orbit in circles around the Sun; planets are thus often on opposite sides from the Sun, and on average the planet closest to that center is the closest to every other planet orbiting that center. Reading: *Physics Today* https://doi.org/10.1063/PT.6.3.20190312a] • Students estimate the circumference of the Earth by starting with some distance that a student may have a good estimate of, such as the width of the US, and then estimating how many times the US would fit around a globe. • Students use the concept of angular distances to estimate the heights or distances of landmarks around the Oval with a stretched-out arm, the width of fingers/fist, and number of steps. Together with a sketch of planetary orbits, they use logical thinking to figure out that Mercury can only be seen within a ‘fist’ above the horizon, whereas Venus is always within two hand-widths above the horizon, and both just after sunset or before sunrise. As a final step, students continue this reasoning to figure out where to find each planet in the sky (even when invisible during the day). • Students make a sketch and some basic calculations to realize that when we see a ‘half moon’ in the sky, they themselves, sitting in their chair, will be at that exact some location in space 2 hours later (or earlier, depending on first-quarter or second-quarter moon phase). • Students design a scientific experiment to test whether astrological horoscope match their zodiac signs (inevitably demonstrating that only 1/12th of students correctly pick their own horoscope when the zodiac/month is blinded). Reading: Lower, S. “Treating astrology's claims with all due gravity”, *Nature* **447**, pg 528 (2007)

	• After learning about the necessity of a moderate greenhouse effect on Earth to allow liquid water – as compared to Mars (too thin atmosphere) and Venus (too much CO_2 in atmosphere) – students perform back-of-the-envelope calculations to convince themselves how easy it is for human CO_2 emissions to increase the delicate 0.04% fraction of CO_2 in our own thin and tenuous atmosphere. • As described in more detail below, students combine concepts from all lectures in a semester-long group project.
ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or ideas within this theme	As described further in response to ELO 2.1 below, students work in small groups throughout the semester to apply what they learn in this class to plan a first human settlement on an assigned planet or moon. Specific suggestions for the students include, e.g., 1) what trajectory would you use for your space craft to get there (taking advantage of gravitational slingshot effects), 2) where would you establish your settlement, taking into account temperatures/climate/weather/resources, 3) what resources would you try to bring versus what resources might be locally available (e.g., water, minerals, oxygen), 4) what are the main environmental challenges and how might you deal with those, 5) how would you communicate with loved ones still on Earth. Not surprisingly, students incorporate many concepts from recent SciFi blockbusters, such as the Martian and Inception, but every year there are also many clever plans for next generation rocket designs, floating cities in the atmospheres of Jovian Gas Giants, and alternative food sources. The exercise also involves literature review, properly citing references, teamwork, constructing effective visual aids, and oral presentation of results to a broad audience.
ELO 2.1 Identify, describe, and synthesize approaches or experiences.	At the start of the course, all students are put in 5-6 student groups that are carefully curated with students from different colleges/majors, freshmen to seniors, and other considerations to build interdisciplinary and diverse teams. A Carmen module lays out the advantages and ground rules for working in such teams (Margaret Heffernan TED talk https://youtu.be/Vyn_xLrtZaY). The objective of the project is for each team to develop a scientific proposal to establish a first human settlement on an assigned planet, moon, asteroid, or comet in our own Solar System or another planetary system (updated annually with new discoveries such as the Trappist planets). Students are required to both incorporate the basic physics laws taught in this and prior courses -and-bring their own background to the table in considering what social science, arts/dance, law, medical, pedagogical, engineering, etc. aspects to consider in their plans. This exercise inevitably leads to animated group discussions between, e.g., the engineer focused on rocket design, the social scientist anticipating the adverse effects of social isolation, agricultural challenges, medical concerns, or the writer/historian that wants to provide first-hand documentation of these historical events.

ELO 2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment, and creative work, building on prior experiences to respond to new and challenging contexts.	This ELO too is embedded in the semester-long group project referenced above. Students regularly meet with their team-members to discuss what they have learned in the last lecture/labs and how to incorporate this into their mission plans. In the first weeks of the semester, a plan to establish a settlement on a remote moon of Saturn typically involves something like 'flying straight there in a turbocharged rocket with enough water to sustain the settlement', while reflections on later lectures illustrate how to evaluate payload weight limitations and the advantages of seemingly crazy space-ship trajectories that 'bounce' from planet to planet before sling-shotting to the final destination; and that ample water may be available, albeit frozen, on such moons. Creativity is paramount in succeeding in this project. In addition, the course has initial and final student surveys, as well as similar questions embedded in midterms, to gauge how students' opinions and understanding of critical concepts such as climate change, the ages of Earth and the Universe, evolution, etc. evolve over the course of the semester. Finally, the course includes weekly quizzes that are graded but are only a minor component of grading scheme. These quizzes provide students with regular feedback on whether or not they are effectively absorbing the material and allow early intervention when necessary (e.g., an office hour to discuss study methods).

Goals and ELOs unique to Origins & Evolution

Below are the Goals and ELOs specific to this Theme. As above, in the accompanying Table, for each ELO, describe the activities (discussions, readings, lectures, assignments) that provide opportunities for students to achieve those outcomes. The answer should be concise and use language accessible to colleagues outside of the submitting department or discipline. The ELOs are expected to vary in their "coverage" in terms of number of activities or emphasis within the course. Examples from successful courses are shared on the next page.

GOAL 3: Successful students will appreciate the time depth of the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.

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ELO 3.1 Illustrate their knowledge of the time depth of the universe, physical systems, life on earth, humanity or human culture by providing examples or models.	To illustrate the time depth of both the entire Universe and of Humanity, students again use the power of a scale model (Week 1 reading and exercises). By scaling the vast times between the Big Bang and today to a 1-year calendar, students develop a better intuition of the relative time periods between important events in the history of the Universe and humanity. Specifically, on this scale our Milky Way Galaxy started to develop in May, the Solar System formed in

	September, the first multicellular life forms in December; large dinosaurs on Dec 25th, the first mammals on Dec 27th, apes/monkeys on Dec 31st; the origin of our species occurred around 8pm on that last day of this 'year', and most of human history occurred in only the last minute. In the same module (Week 1), students are reminded that, because of the finite speed of light, looking into space means looking back in time. We explore several examples, such as 1) 'the 7 minutes of terror' in landing the Perseverance Rover on Mars and now knowing whether it landed or crashed during the 7 minutes it takes for any signal to reach Earth from Mars (plus another 7 minutes to send, e.g., a course correction), 2) the 1997 movie *Contact* in which an alien signal from Vega rebroadcasts the first 'message' it received from Earth in the form of WWII broadcasts, taking 25 (light) years to reach Vega and 25 years for an 'answer' to return, and 3) how a potential civilization in the Andromeda galaxy pointing a telescope at us would see *Homo habilis* humanoids roaming the Earth in the Pleistocene (2.5 million years ago). Similarly, in the semester-long group project, students have to contemplate and discuss how communication would work between their extraterrestrial colony and a remaining population on Earth. In an entirely different example of the time depth of a physical system and life on Earth, students a learn about climate records, e.g., from ice cores such as those archived in OSU's renowned Byrd Polar and Climate Research Center. These records go back more than a million years in Antarctica and provide a clear context for the exceedingly fast changes since the industrial revolution. Reading: https://www.nature.com/articles/d41586-022-02129-5
ELO 3.2 Explain scientific methods used to reconstruct the history of the universe, physical systems, life on earth, humanity or human culture and specify their domains of validity.	In Week 1, we discuss how already ancient Greeks (in modern day Egypt) accurately estimated Earth's circumference by measuring Sun angles from two locations at the exact same time. Week 4 of the course is devoted specifically to the History of Science and the development of what we now call the 'Scientific Method' of iterating between observations, hypotheses, experimental/observational tests, and re-evaluating theories once confronted with incompatible measurements. Students learn what scientific arguments were used in the Copernican revolution to go from an Earth-centered model of the Universe consisting of perfect spheres to our current understanding of imperfect 'lumpy' objects circling each other (planets, stars, galaxies, clusters), both through the mathematical models by Kepler and Newton and the experiments and first telescope observations by

	Galileo. Later (Week 5), we discuss how despite Einstein's theories of relativity, Newton's simpler models can still be used as a suitable approximation under weak gravity conditions. Week 6 is devoted to properties of light. First, students learn to appreciate how incredible our knowledge is of even the furthest reaches of our Universe, even though we have never, and will never, visit there. Everything we know about extraterrestrial planets, stars, galaxies, black holes, supernovae etc etc is derived from the light that travels from those places to us. Students then learn the basic quantum mechanical principles that explain emission, absoption, and continuum spectra. As a hand-on experience, students make their own spectrometer from a TP roll, a CD, and a bussiness card. They then look at different light sources (directly, or reflecting of other surfaces), such as the Sun, an incandescent light bulb, a phone or laptop monitor, a CFL bulb, etc., and figure out how that light was created. The same module explains why Earth's sky is blue and sunsets red, why we don't see stars during the day (which is not true on, e.g., the Sun-facing side of the Moon), and what determines the colors of surfaces. The same scientific methods and principles are used in Week 9 to understand how our, and other planets', atmospheres work, blocking harmful radiation from the Sun, providing a greenhouse effect, forming clouds that can distribute water/rain, why it contains a large fraction of oxygen (because of Life!), and more; all necessary ingredients for the origin and evolution of Life as we know it. Similarly, in Week 8, students learn what scientific methods were used to suggest the, initially ridiculed, concept of plate motions on Earth (and why plate tectonics does seem to occur on our sister planet Venus). Physics concepts of energy, conduction, and convection from week 5 are used to explain planetary geology. In other reading materials and exercises (see syllabus), students learn different scientific methods to estimate ages in the Solar System and the Universe, such as radioactive age dating, counting craters on the Moon and rocky planets, the red-shift of distant stars and galaxies, and sedimentary records such as: fossils, past major volcanic eruptions, and meteor impacts. As an exampe of the latter, across the globe we can identify the 'K-T' boundary of a thin band of rock with high iridium content from the large meteorite impact at the Chicxulub crater that caused a mass extinction event (incl. dynosaurs), but also started the dominance of mammals and ultimately humans.
ELO 3.3 Engage with current controversies and problems related to origins and evolution questions.	Students are first taught to contextualize early scientific controversies given the knowledge at the time, such as the heliocentric versus geocentric views of the Universe (Week 4), early theories of the formation of our Solar System that were later disproven (Week 7), and the long road to acceptance of the theory of plate tectonics (Week 8). Importantly, we also discuss the social, political, and

	religious conditions that influenced discussions regarding origins and evolution over time. Controversies around Darwin's theory of evolution are discussed in the context of the Scientific Method in Week 7. Students learn that scientists (should) never dogmatically believe in any particular theory, but rather that theories are the best explanation at a given time of a wide range of past, current, and hopefully future independent observations; however, a theory is modified or discarded when sufficient new observations can no longer be explained (leading to, e.g., quantum mechanics and special/general relativity). As an example, we use Astro**logy,** and students are asked to come up with their own empirical experiments to -test- whether astrological predictions are true or false in a scientific/statistical sense (as described above). In Week 9, we discuss controversies around human impacts on our atmosphere and its dangers to our survival. We start with success stories of how international collaboration prevailed in tackling, e.g., 'acid rain' and 'the holes in the ozone layer', before diving into current climate change due to anthropogenic greenhouse gas emissions. As an illustration of the associated politics, students watch a political ad from the 90's in which Nancy Pelosi and Newt Gingrich sit on a couch together and proclaim that they disagree on many fronts but obviously agree on the need to reduce CO_2 emissions. Readings on this topic are updated each year to reflect the current status of climate change and efforts at mitigation, and include "Talking to science deniers and skeptics is not hopeless" McIntyre, *Nature* **596** (2021) In Week 12, we discuss Exoplanets -with many more discovered each year-, how those planetary systems are different from our own, and how they challenge some of our understandings of how our Solar System formed. Planetary science is a highly active field and each year there are new discoveries with surrounding controversies that we discuss, such as whether or not the latest findings on Mars prove the past existence of Life on that planet (*Nature* **619**, pages 724–732 (2023)), whether we will find life on distant moons like Europa or Enceladus (*Nature* **618**, pg 489–493 (2023)), whether and where we will find a Planet Nine to take Pluto's former title as the 9^{th} planet (https://www.nature.com/articles/d41586-021-00456-7), and what the latest estimates are of the age of the Universe (https://www.usatoday.com/story/news/nation/2023/07/14/universe-may-older-than-thought-study-shows/70411343007/). Such readings are updated annually, including both press releases on, e.g., NASA websites and peer reviewed literature (such as the references above). The Carmen course has a separate module "Planets in the Press" that is updated frequently throughout the semester with more information than we can cover in depth.

	Throughout the semester, students also debate the chances of (existence/meeting/communicating with) extraterrestrial life, in terms of making educated guesses of the likelihood (along the lines of Drake's equation), as well as recent developments, such as the recent UFO hearings in Congress, and a new effort at detecting extraterrestrial *technology* (Reading: https://www.nytimes.com/2022/09/15/magazine/extraterrestrials-technosignatures.html).
ELO 4.1 Describe their knowledge of how the universe, physical systems, life on Earth, humanity or human culture have evolved over time.	The evolution over time of the Universe, our Solar System, planet Earth, the origins and evolution of life on Earth (and potentially elsewhere), and the development of human culture and Science are the subject of this entire course. Students' knowledge of these subjects is assessed extensively. Each week has one check-in quiz and a subject-matter quiz. Each of the three sections of the course ends with a midterm that covers all material in that section. And – perhaps more interestingly- at the end of the semester each group of 5-6 students presents their proposal for a human colony on an extraterrestrial object (other planet, dwarf planet, moon, asteroid, comet), which requires students to creatively synthesize their knowledge on how the evolution of Earth made human life possible here, and how to try and replicate this elsewhere.
ELO 4.2 Summarize current theories of the origins and evolution of the universe, physical systems, life on earth, humanity or human culture.	This ELO is addressed in the same fashion as the previous ELO 4.1, i.e. to 'describe their knowledge of' will require to 'summarize current theories of' how the Universe started with a Big Bang and inflationary period, what the current theory is of the formation of our Solar System, and what the necessary ingredients were and are for life on Earth (or elsewhere).