Term Information

Effective Term	Spring 2023
Previous Value	*Autumn 2020*

Course Change Information

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

Requesting inclusion in the new GE Theme Origins and Evolution.

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

The new GE Theme Origins and Evolution has been approved and this course is a natural fit.

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	Astronomy
Fiscal Unit/Academic Org	Astronomy - D0614
College/Academic Group	Arts and Sciences
Level/Career	Graduate, Undergraduate
Course Number/Catalog	5205
Course Title	Planetary Science
Transcript Abbreviation	Planetary Science
Course Description	A multidisciplinary approach to planetary science, integrating modern methods with the Earth and Astrophysical Sciences. Team-taught with faculty in Earth Sciences.
Semester Credit Hours/Units	Fixed: 3

Offering Information

Length Of Course	14 Week, 12 Week, 8 Week, 7 Week, 6 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
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*

Prerequisites and Exclusions

Prerequisites/Corequisites	Prereq: Math 1152 or Grad standing.
Previous Value	*Prereq: Math 1152 and a GE Data Analysis course, or permission of instructor.*
Exclusions	Not open to students with credit for EarthSc 5205.
Electronically Enforced	Yes

Cross-Listings

Cross-Listings	Cross-listed in EarthSc.

Subject/CIP Code

Subject/CIP Code	40.0601
Subsidy Level	Doctoral Course
Intended Rank	Junior, Senior, Masters, Doctoral

Requirement/Elective Designation

Required for this unit's degrees, majors, and/or minors
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

- (1) place current knowledge of planetary science in the broader context of the Earth and Astrophysical Sciences
- (2) integrate geophysical and astrophysical datasets to test scientific hypotheses across planetary time- and lengthscales
- (3) apply systems-level thinking to planetary-scale scientific questions

Content Topic List

- Introduction to Planetology
- Measuring Stars
- Measuring Planets
- Nucleosynthesis overview
- Connection between the Stars and the Planets: Cosmochemistry
- Connection between the Stars and the Planets: Planetary formation models as informed by cosmochemistry & exoplanetary system dynamics
- Planetary interior modeling
- Planetary Atmospheres & Atmospheric escape
- Astrobiology

Sought Concurrence No

Attachments

- EARTHSC-ASTRON 5205 syllabus_submitted.docx: syllabus
  (Syllabus. Owner: Pinsonneault,Marc Howard)
- EARTHSC-ASTRON 5205 OE responses.docx: ELO questionnaire
  (GEC Model Curriculum Compliance Stmt. Owner: Pinsonneault,Marc Howard)

Comments

- mirror request to one submitted by Earth Sciences *(by Pinsonneault,Marc Howard on 09/09/2022 12:43 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Pinsonneault,Marc Howard	09/09/2022 12:43 PM	Submitted for Approval
Approved	Weinberg,David Hal	09/22/2022 02:33 PM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	09/22/2022 02:37 PM	College Approval
Pending Approval	Cody,Emily Kathryn Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	09/22/2022 02:37 PM	ASCCAO Approval

ASTRON/EARTHSC 5205
Planetary Science

Instructors
Professor Panero, School of Earth Science
377 Mendenhall Labs
614-292-6290
panero.1@osu.edu
Office hours by appointment, zoom ok

Professor Wang, Department of Astronomy
4003 McPherson Lab
614-514-5897
wang.12220@osu.edu
Office Hours on Zoom: Monday 1:00PM-2:00PM and by appointment

Meeting Time and Location
MW 2:20-3:40 pm; McPherson 1005

Course Catalog Description
A multidisciplinary approach to planetary science, integrating modern methods with the Earth and Astrophysical Sciences. Team-taught with faculty in Astronomy.
Prereq: Math 1152 and a GE Data Analysis course, or Grad standing, or permission of instructor.

Recommended Texts:
The Exoplanet Handbook (Michael Perryman) Available online through OSU libraries
Exoplanets (Sara Seager) E-book available through OSU libraries
Fundamental Planetary Science: Physics, Chemistry and Habitability (Imke de Pater and Jack J. Lissauer)

Additional reading material will consist of published work in the peer reviewed literature, which will be available to students on Carmen.

The class fulfils one of the requirements of the Planetary Science Certificates. Please see Dr. Panero or Dr. Wang if you have any questions about certificate opportunities.

Students starting at Ohio State in Autumn 2022 and beyond*: ASTRON/EARTHSC 5205 will count as any one (and only one) three-credit course in the* ***Origins and Evolution*** *new General Education (GE) Theme. Note: Even though it is a team-taught course, it is not considered an integrative practice course and only partially fulfills this GE Theme requirement.*

The goals of the *Origins and Evolution* GE Theme:

Successful students will:

1. Analyze the origins and evolution of natural systems, life, humanity, or human culture at a more advanced and in-depth level than in the Foundations component.
2. Integrate approaches to the origins and evolution of natural systems, life, humanity, or human culture by making connections to their own experiences and by making connections to work they have done in previous classes and/or anticipate doing in the future.
3. 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.

4. Understand the origins and evolution of natural systems, life, humanity, or human culture, and the factors that have shaped them over time.

More specifically, the Expected Learning Outcomes for this theme are:
Successful students will be able to:

1.1 Apply their understanding of scientific methods to quantitative calculations.
1.2 Engage in critical and logical thinking about the origins and evolution of the universe, physical systems, life on Earth, humanity, or human culture.
2.1 Identify, describe, and synthesize approaches to or experiences of origins and evolution questions in different academic and non-academic contexts.
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.
3.1 Illustrate the time depth of the universe, physical systems, life on Earth, humanity, or human culture by providing examples or models.
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.
3.3 Engage with current controversies and problems related to origins and evolution questions.
4.1 Describe how the universe, physical systems, life on Earth, humanity, or human culture have evolved over time.
4.2 Summarize current theories of the origin and evolution of the universe, physical systems, life on Earth, humanity, or human culture.

How will *this* course fulfill the goals and Expected Learning Outcomes? Students in this course will consider habitability of other planets through lecture, class discussion, and group problem solving to address the temperature of atmospheres, stability of water, and the effects of a greenhouse on planets surrounding a variety of types of stars. These results will be used to link the compositions of planets to the composition of their host stars. Through in-class calculations and demonstrations, students will work to understand the age of the Solar System, and how the understanding of the Solar System age has *evolved* over the last two centuries. Students will read and critically evaluate four transformational papers addressing the *origins* of planets, including planetary migration, water delivery to inner solar system objects, the meter barrier problem, and the origins of the exoplanet radius gap. Students will also identify, describe, and synthesize the *origins* of planets through back of the envelope calculations of pebble migration, energy of planetesimal accretion, and origins of planetary heat.

Upon successful completion of the course, students will be able to

(1) place current knowledge of planetary science in the broader context of the Earth and Astrophysical Sciences
(2) integrate geophysical and astrophysical datasets to test scientific hypotheses across planetary time- and spatial- scales.
(3) apply systems-level thinking to planetary-scale scientific questions.

Upon successful completion of this course, we expect students will improve their skills in:

(1) Being an independent researcher and thinker
(2) Making order of magnitude calculations
(3) Effective and efficient reading of the literature
(4) Presentation of scientific work orally and in writing
(5) Work collaboratively as part of a team with diverse skillsets to solve problems requiring expertise across the skillsets.

Grading:

Team projects (4 projects) 60%

Each project is worth 15%

1/3 team grade from peer evaluation of your project

1/3 self-evaluation

1/3 assigned by Profs Wang and Panero

Paper summary presentations 20% (4 papers)

Each group will present once.

Students not in the group presenting will submit 1 paragraph summary of the paper before class

Attendance and in-class engagement 20%

15% is for class attendance

5% is credit for class discussion and engagement of peer evaluation

Weekly topical outline of course meetings, topics to be covered, readings, and homework

The topics are likely to change and adjust as we go based on pacing and student interest

Date	Topic	Assignments due on Wednesdays
Week 1 Jan 10-12	Introduction to Planetology & course overview and philosophy Tour of the solar system (Panero) Ice breaker, skills assessment, team formation, discussion of teamwork vs groupwork Assign Paper 1	
Week 2 Jan 17-19	Tour of exoplanets, populations (Wang) Roll out Project 1: *Exoplanet Data Explorer and Calculating Detection Signal of Different Methods*	Paper 1 presentation (group 1)
Week 3 Jan 24-26	Measuring Planets and the Mass-Radius Relation, Size, mass, and structure (Wang)	
Week 4 Jan 31-Feb2	Understanding the influence of stars on measuring planets, Stars and stellar activity (Wang)	Project 1
Week 5 Feb 7-9	Nucleosynthesis overview (Wang) Connection between the Stars and the Planets: Cosmochemistry; evidence from meteorites (Panero) Roll out Project 2: *Measuring Planet Mass, Radius, and Density* Roll out Paper 2 Feedback survey #1	Peer evaluation of project 1
Week 6 Feb 14-16	Connection between the Stars and the Planets: Planetary formation models as informed by cosmochemistry & exoplanetary system dynamics (Wang & Panero)	Paper 2 presentation (group 2)
Week 7 Feb 21-23	Planetary interior modeling (Panero)	Project 2

Week 8 Feb 28-Mar 2	Planetary Atmospheres & Atmospheric escape: Earth, Mars, Venus, & Titan (Panero) Roll out Paper 3 Feedback survey #2	Peer evaluation of project 2
Week 9 Mar 7-9	Planetary Atmospheres: Jupiter & Ice Giants (Wang) Roll out project 3: *Measuring Stellar Abundance*	Paper 3 presentation (group 3)
Week 10 Mar 21-23	Planetary Atmospheres: Exoplanets (Wang)	
Week 11 Mar 28-30	Astrobiology: Habitability, biosignatures, discussion of evolution of life on Earth (Panero) Observational approaches (Wang)	Project 3
Week 12 Ap 4-6	Astrobiology: Observational approaches (Wang) Roll out Paper 4 Roll out project 4: *Build-A-Planet* Feedback survey #3	Peer evaluation of project 3
Week 13 Ap 11-13	Major unsolved problems (Wang & Panero)	Paper 4 presentation (group 4)
Week 14 Ap 18-20	Major unsolved problems (Wang & Panero)	Project 4
Week 15 Ap 25	Summative Discussion	(Monday) Self evaluation of project 4 and team learning/progress.

Team projects:
You will have 4 projects to complete as a team this semester. The projects will explore aspects of modern planetary science through exercises designed to build familiarity with methods, tools, and approaches to planetary science. Students will work in assigned teams, in which teams will be built so that members have complementary skill sets and/or scientific background.

You must be an active member of your team for the team to succeed. You need to coordinate tasks, collaborate with each other, and set and meet intermediate deadlines so that your team will be ready to present in class on the due date. Falling behind in the class will not only impact you, but also impact the rest of the team. If you are ill, you need to reach out to your team to negotiate readjusting assigned tasks, as well as to contact your professors. We will not penalize students for late work unless it becomes habitual.

Each team project consists of a written report and a 10-minute oral presentation. Teams should rotate who is writing lead and who is the presenter throughout the semester. See the project descriptions for the specific requirements for each.

Submission: As a team, you will upload your written report and original codes in producing results in the report on GitHub. Instructions of creating an account and managing your code repository will be given during class.

Grading: Your grade on each project will come from three sources: 1/3 team grade from peer evaluations of your project, 1/3 self-evaluation as submitted in Carmen, and 1/3 assigned by Profs Wang and Panero.

The faculty-assigned grades will reflect not only the quality of the project but also an assessment of your individual contributions and growth as a team member.

Peer evaluation of projects: As a team, you will submit a written evaluation of the oral presentation and written report from another team. A few points to bear in mind during the evaluation of the oral presentation are:

- Is the presentation well-motivated?
- Are all the assumptions and calculations clearly laid out?
- Are the results sensible?
- Are the slides appealing and clear?
- Are all the questions from the audience properly addressed?

Points to bear in mind during the evaluation of the written report:

- Is the report well-motivated and placed in context?
- Are all the assumptions and calculations clearly laid out?
- Are the results sensible?
- Are the figures appealing and clear?
- Is there a clear conclusion and suggestions for next steps?

Self-evaluation instructions:
Submit a 2-3 paragraph description of your own role in your team for each project. It should include

- An assessment of how your team is working together
  - describe how intermediate tasks and deadlines were decided and set within your team
  - describe how team members communicated and collaborated
- An assessment of how you performed as a team member.
  - include what you led for the project, where you contributed in a supporting role, and where you relied on others in the team.
  - describe how well you met intermediate deadlines as set by yourself and your team
- Describe how you would like to improve your performance as a team member in future projects.

Paper presentations:

We will read 4 important papers in planetary sciences this semester. Each student is responsible for reading each paper and fully participate in the discussion of the papers in class. Each paper discussion will be led by a different team.

Team presentations: Your team will lead a presentation of one paper this semester with powerpoint at the start of class on that day. You will give a 15-minute (1 pt for keeping w/in 15 min), provide an overview and discussion of the paper, place put the paper in context (1 pt), including the objective (1 pt), the methods (include key figures) (1 pt), results (1 pt), and conclusion (1 pt).

Your discussion of the figures should tell the class how to interpret the figures (1 pt) and how the results arise from the methods used (1 pt). Similarly, your description of the conclusion should explain how the results lead to the conclusion (1 pt) and the degree to which they address the initial objective (1 pt).

The presentation should be uploaded to Carmen prior to the start of class.

Individual assignment: Students not part of the group presenting must submit a 1-paragraph summary describing, in your own words (1 pt), the objective of the paper (1 pt), the methods or approach used (1 pt), main results (1 pt), and conclusion (1 pt). No need to submit a paper review on the week you will present the paper. *Due before class on the date listed.*

Attendance and Participation: What can we say as we embark on 2020 version 3? Perfect attendance is not something that any rational person should expect or require. Instead, we ask you to take this class seriously, participate thoughtfully in class*, and let us know if you'll miss class*. If non-attendance becomes a pattern, we will ask you to talk to us about what's keeping you from class so that we can make a plan to support your learning.

While a lot of the class is presented as lecture, we rely on student engagement to move the discussion and content forward. We will also integrate sessions to help you get started on your projects. Missing class also means missing paper and project discussions, which cannot be done independently.

Grading scale

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

Credit hour and work expectation

This is a 3-credit-hour course. According to Ohio State policy, students should expect the scheduled direct instruction in addition to 6+ hours of homework (reading and assignment preparation, for example) to receive a grade of (C) average. ASC Honors provides an excellent guide to scheduling and study expectations.

Course technology

For help with your password, university e-mail, 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 24x7.

- **Carmen:**
  - Carmen, Ohio State's Learning Management System, will be used to host materials and activities throughout this course. To access Carmen, visit Carmen.osu.edu. Log in to Carmen using your name.# and password. If you have not setup a name.# and password, visit my.osu.edu.
  - Help guides on the use of Carmen can be found at https://resourcecenter.odee.osu.edu/carmen
- **Carmen Zoom:**
  - Office hours will be held through Ohio State's conferencing platform, Carmen Zoom. A separate guide to accessing Carmen Zoom and our office hours is posted on the course Carmen page under Files.

  - Students may use the audio and video functions if a webcam and microphone are available. If not, there is still a chat function within Carmen Zoom for the student to live chat with the professor or TA in the virtual office hours room.
  - Carmen Zoom help guide
- **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 necessary for online courses
- Basic computer and web-browsing skills
- Navigating Carmen

Necessary equipment
- Computer: current Mac (OS X) or PC (Windows 10+) with high-speed internet connection
- Web cam and microphone
- Camera capable of taking pictures of your work for upload. Please reach out to me if you don't have access to something that can do this.

Necessary software
- Word processor with the ability to save files under .doc, .docx, .rtf, or .pdf. Most popular word processing software programs including Microsoft Word and Mac Pages have these abilities.
- OSU students have access to Microsoft Office products free of charge. To install, please visit https://osuitsm.service-now.com/selfservice/kb_view.do?sysparm_article=kb04733
- Python is recommended for the class because many class projects have tutorials written in Python. See https://docs.anaconda.com/anaconda/install/ for instructions in installing Python on your computer.

Student Academic Services

Arts and Sciences Advising and Academic Services' website provides support for student academic success. Information on advising issues such as tutoring, transfer credits, academic standing, and contact information for Arts and Sciences advisors can be obtained through this website. The site is: http://advising.osu.edu/welcome.shtml

Student Services

The Student Service Center assists with financial aid matters, tuition and fee payments. Please see their site at: http://ssc.osu.edu

Copyright Disclaimer

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.

Diversity

The School of Communication at The Ohio State University embraces and maintains an environment that respects diverse traditions, heritages, experiences, and people. Our commitment to diversity moves beyond mere tolerance to recognizing, understanding, and welcoming the contributions of diverse groups and the value group members possess as individuals. In our School, the faculty, students, and staff are dedicated to building a tradition of diversity with principles of equal opportunity, personal respect, and the intellectual interests of those who comprise diverse cultures.

Title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Interim Ohio State Title IX Coordinator, Molly Peirano, at titleix@osu.edu

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. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing.
If you are or someone you know is suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614--292--5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at 614-292-5766.
If you are thinking of harming yourself or need a safe, non-judgmental place to talk, or if you are worried about someone else and need advice about what to do, 24-hour emergency help is also available through the Suicide Prevention Hotline (Columbus: 614-221-5445)

COVID-19 and Illness Policies

University COVID policies

The university strives to make all learning experiences as accessible as possible. 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. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let us know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Student illness or absence

In the event you must quarantine because of exposure to someone diagnosed with COVID-19 OR you are feeling ill with COVID-19 symptoms, you still will be able to make progress in this class. Please contact **BOTH** Drs. Panero & Wang right away, as some accommodations may require extra set-up or planning. The quarantine plan for this course is to

-join remotely via Zoom. This requires advance notice for device and room set-up.
-record the class session (Zoom first two weeks; mediasite and/or Zoom after that) and post the recording on Carmen.

If *you* are too ill to participate in this course due to COVID-19 or another illness, please contact **BOTH** Drs. Panero & Wang as soon as you are able prior to the next class meeting. All materials will be made available on Carmen, including lecture recordings and slides.

Instructor illness or absence

If the *instructor* is quarantined or is experiencing respiratory symptoms but is well enough to teach, the in-person sessions will be moved online to Zoom. You will be notified via email prior to class.
If the *instructor* is too ill to teach the course for a period of time, we will rearrange the schedule so that the other instructor can take over.

Campus closure

Should Ohio State University Main Campus move to full online instruction due to closure, please wait for your instructor to email directions for the next session. Our in-person classes will be moved to Zoom and links to the meetings will be provided.

Academic integrity policy

- **Written assignments**: Your written assignments, including discussion posts, should be your own original work. You must cite your sources, including the sources of images.
- **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 us.
- **Falsifying research or results**: All lab work you will conduct in this course is intended to be a learning experience; you should never feel tempted to make your results look more successful than it was.

Academic Misconduct

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc/

Accessibility accommodations for students with disabilities

Requesting accommodations

The university strives to make all learning experiences as accessible as possible. 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. 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. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion. SLDS contact information: slds@osu.edu; 614-292-3307; slds.osu.edu; 098 Baker Hall, 113 W. 12th Avenue.

Responses for:

EARTHSC/ASTRON 5205 Planetary Science

Overview

Courses that are accepted into the General Education (GE) Themes must meet two sets of Expected Learning Outcomes (ELOs): those common for all GE Themes and one set specific to the content of the Theme. This form begins with the criteria common to all themes and has expandable sections relating to each specific theme. A course may be accepted into more than one Theme if the ELOs for each theme are met. Courses seeing approval for multiple Themes will complete a submission document for each theme. Courses seeking approval as a 4-credit, Integrative Practices course need to complete a similar submission form for the chosen practice. It may be helpful to consult your Director of Undergraduate Studies or appropriate support staff person as you develop and submit your course.

Please enter text in the boxes to describe how your class will meet the ELOs of the Theme to which it applies. Please use language that is clear and concise and that colleagues outside of your discipline will be able to follow. You are encouraged to refer specifically to the syllabus submitted for the course, since the reviewers will also have that document Because this document will be used in the course review and approval process, you should be *as specific as possible*, listing concrete activities, specific theories, names of scholars, titles of textbooks etc.

General Expectations of All Themes

GOAL 1: Successful students will analyze an important topic or idea at a more advanced and in-depth level than the foundations. Please briefly identify the ways in which this course represents an advanced study of the focal theme. 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.

In this course, students engage in team science, building on the foundations laid in prerequisite courses or as presented in class, to tackle four projects illustrating the research process in modern Planetary Science. Students also read and analyze four transformational papers written in the last 15 years addressing our evolving understanding of planetary formation. See course ELOs, "place current knowledge of planetary science in the broader context of the Earth and Astrophysical Sciences."

ELO 1.1 Engage in critical and logical thinking about the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students critically evaluate four transformational papers written in the last 15 years addressing our evolving understanding of planetary formation. They identify and evaluate literature sources for reference values for their projects that explore aspects of modern planetary science, and evaluate their own results as well as evaluate the results of peers. See course ELO, "apply systems-level thinking to planetary-scale scientific questions."

ELO 1.2 Engage in an advanced, in-depth, scholarly exploration of the topic or idea of the theme. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students tackle four projects that demonstrate modern planetary science topics. See course ELO, "integrate geophysical and astrophysical datasets to test scientific hypotheses across planetary time- and spatial- scales."

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. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students will "place current knowledge of planetary science in the broader context of the Earth and Astrophysical Sciences," "apply systems-level thinking to planetary-scale scientific questions," "Work collaboratively as part of a team with diverse skillsets to solve problems requiring expertise across the skillsets." These ELOs are fulfilled and assessed in the team projects, paper presentations and peer evaluations as described above.

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. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students are all members of a team throughout the semester. For each team project, part of their assignment is to write a 2-3 paragraph assessment of their own performance in the context of the functioning of their team, including goal *reflection* on the efficacy of their performance and *goal setting* for how they will adjust their approach for subsequent projects. See course ELOs, "Being an independent researcher and thinker" and "Work collaboratively as part of a team with diverse skillsets to solve problems requiring expertise across the skillsets."

Specific Expectations of Courses in Origins and Evolution

GOAL 1. Students will analyze the origins and evolution of natural systems, life, humanity, or human culture at a more advanced and in-depth level than in the Foundations component.

ELO 1.1 Apply their understanding of scientific methods to quantitative calculations. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students perform order-of-magnitude or "back of the envelope" calculations in each class session, often working as groups. These exercises build intuition into the quantitative results required by the team projects. *Example*: students calculate the approximate pressure of the center of the Earth using basic Earth data, serving as a "sanity check" for their use of planet-building code in Project 4. See course ELO, "Making order of magnitude calculations."

ELO 1.2 Engage in critical and logical thinking about the origins and evolution of the universe, physical systems, life on Earth, humanity, or human culture. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students consider habitability of other planets through lecture, class discussion, and group problem solving to address the temperature of atmospheres, stability of water, and the effects of a greenhouse on planets surrounding a variety of types of stars. See course ELO, "integrate geophysical and astrophysical datasets to test scientific hypotheses across planetary time- and spatial- scales."

GOAL 2. Students will integrate approaches to the origins and evolution of natural systems, life, humanity, or human culture by making connections to their own experiences and by making connections to work they have done in previous classes and/or anticipate doing in the future.

ELO 2.1 Identify, describe, and synthesize approaches to or experiences of origins and evolution questions in different academic and non-academic contexts. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students identify, describe, and synthesize the origins of planets through back of the envelope calculations of pebble migration, energy of planetesimal accretion, and origins of planetary heat. These results are used in Project 3 and 4 in which the compositions of planets are linked to the composition of their host stars.

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. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students write an extensive self-reflection of their performance as a team member after each project. See course ELO, "Work collaboratively as part of a team with diverse skillsets to solve problems requiring expertise across the skillsets."

GOAL 3. 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 the time depth of the universe, physical systems, life on Earth, humanity, or human culture by providing examples or models. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students work to understand, through in-class calculations and demonstrations, the age of the Solar System, and how the understanding of the Solar System age has evolved over the last two centuries. See course ELO, "Making order of magnitude calculations."

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. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students apply the scientific method in Project 1 to calculate the detectability of a model exoplanet given state-of-the-art measurement techniques, use their results in Project 2 to calculate the size and mass of a planet, then place the planet in context of planet type and possible origin.

ELO 3.3 Engage with current controversies and problems related to origins and evolution questions. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students read and critically evaluate four papers addressing the origins of planets, including planetary migration, water delivery to inner solar system objects, the meter barrier problem, and the origins of the exoplanet radius gap. See course ELO, “Effective and efficient reading of the literature.”

GOAL 4. 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 how the universe, physical systems, life on Earth, humanity, or human culture have evolved over time. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students address evidence for the origin and evolution of planets, primarily Solar System objects, including the change in Earth’s oxygen content of the atmosphere over 4.5 billion years, evidence for early water on Earth, and the rise of plate tectonics. See course ELO, “integrate geophysical and astrophysical datasets to test scientific hypotheses across planetary time- and spatial- scales.”

ELO 4.2 Summarize current theories of the origin and evolution of the universe, physical systems, life on Earth, humanity, or human culture. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

In this course, students write four reports and oral presentations on their projects, summarizing the motivation of the project and chosen subtopic, including, for instance, the link between host star abundances and the composition of a chosen exoplanet the team models. See ELOs, “(1) place current knowledge of planetary science in the broader context of the Earth and Astrophysical Sciences, (2) integrate geophysical and astrophysical datasets to test scientific hypotheses across planetary time- and spatial- scales., (3) apply systems-level thinking to planetary-scale scientific questions.”