

Fundamentals of Planetary Science II

Course Syllabus – AST 502

Department/Academic Unit: Astronomy and Planetary Science

Term/Year: Spring, 2024

Total Units of Course Credit: 3

Mode of Instruction: face-to-face

General Information:

- Class Times: M/W/F 11:30 am – 12:20 pm
- Location: Physical Sciences (Bldg #19) Room 111
- Instructors: Profs. Devon Burr and Josh Emery
 - Email: Devon.Burr@nau.edu and Joshua.Emery@nau.edu
 - Offices: Physical Sciences 315 and 323/324
 - Office Hours: Monday 2-3 pm and by appointment

~Welcome to Fundamentals of Planetary Science II~
We're looking forward to this class with all of you.

Course Purpose:

Geophysical and geologic processes occur throughout our Solar System. Thus, an understanding of these processes is a necessary foundation to understanding its past evolution, current state, and habitability potential. This course, following on AST501 Fundamentals of Planetary Science I, serves the PhD program in Astronomy and Planetary Science with the aim of continued development of students as research professionals. Our ambition for each student in the course is: i) the development of a foundational understanding of planetary geophysical and geologic processes, ii) the continued practice of technical (e.g., computational) skills used in planetary science, and iii) an enhanced capacity in reading, understanding and presenting scientific literature, including a knowledge of the scientific methodology of hypothesis testing. These desiderata will be shaped through engagement with the course materials, including by independent work and in collaboration with other students.

Prerequisites: This course is a graduate-level course for students pursuing a graduate degree in astronomy and planetary science or a related field. A working knowledge of undergraduate physics and advanced mathematics (e.g., calculus) is expected, along with a familiarity with geologic and geophysical concepts. We're happy to suggest background reading materials if needed.

Course Student Learning Outcomes:

This course subserves the departmental Student Learning Outcome "Understand the physical processes in the present-day Solar System through high-level problem solving . . ." For students whose research focuses on the study of planetary surfaces, it subserves the further learning outcomes "understand the principles of...planetary system formation...[and] the

physical processes in the present day Solar System...”

(<https://catalog.nau.edu/Catalog/details?plan=ASTPHD&catalogYear=2122>)

Another outcome for this and all NAU courses is enhanced career-readiness, a University-wide initiative at NAU. The following are **Career Ready Resources** available to NAU students:

LinkedIn:

CEFNS Career Development

www.linkedin.com/in/cefns-career-development-072715233

NAU Career Development

<https://www.linkedin.com/company/nau-career-development/>

Handshake:

<https://nau.joinhandshake.com/login>

Udemy: Online courses and career searching advice

<https://in.nau.edu/its/udemy/>

Log in with your NAU email account and search ‘NAU Career Steps’

O*net Online: Occupation exploration reports

<https://www.onetonline.org/>

In addition to these resources, each type of assignment in this course provides practice developing specific **Career Readiness Competencies**, as defined by The National Association of Colleges and Employers (NACE). These competencies are transferable skills that promote successful entrance into the workforce and lifelong career management. They are:

1. **Career & Self-Development**: Proactively develop oneself and one’s career through continual personal and professional learning, awareness of one’s strengths and weaknesses, navigation of career opportunities, and networking to build relationships within and without one’s organization.
2. **Communication**: Clearly and effectively exchange information, ideas, facts, and perspectives with persons inside and outside of an organization.
3. **Critical Thinking**: Identify and respond to needs based upon an understanding of situational context and logical analysis of relevant information.
4. **Equity & Inclusion**: Demonstrate the awareness, attitude, knowledge, and skills required to equitably engage and include people from different local and global cultures. Engage in anti-racist practices that actively challenge the systems, structures, and policies of racism.
5. **Leadership**: Recognize and capitalize on personal and team strengths to achieve organizational goals.
6. **Professionalism**: Knowing work environments differ greatly, understand and demonstrate effective work habits, and act in the interest of the larger community and workplace.
7. **Teamwork**: Build and maintain collaborative relationships to work effectively toward common goals, while appreciating diverse viewpoints and shared responsibilities.
8. **Technology**: Understand and leverage technologies ethically to enhance efficiencies, complete tasks, and accomplish goals.

CRCs exercised in each assignment type are noted next to the assignment types below.

Assignments/Assessments of Course Student Learning Outcomes: The following assignments will be used to encourage and provide feedback on student achievement of the course Student Learning Outcomes:

1) **Homework** [*Career and Self-Development, Communication, Critical Thinking, Technology*]

- There will be seven homework assignments, intended to develop your skill – and thus comfort – with the material presented in class. The ~bi-weekly cadence of these assignments is designed to provide sufficient time for their thoughtful completion, including assimilation of material both presented in class and collected by you out of class. The distribution of points per question will be indicated on each assignment.
- Many homework assignments will be built around calculations. State any assumptions and show neatly, with explanation when necessary, all steps in your work. This practice will both support your correct, logical reasoning and provide experience in explaining your work to others, as is necessary in teaching, scientific collaborations, manuscripts, meeting presentations, etc.
- Homework assignments might also include writing and/or sketching, which are fundamental skills of scientists in communicating their work. When a written response is requested, use complete sentences, correct grammar, correct spelling, and other components of standard scientific English.
- Collaboration is a hallmark of modern science. *Please feel free to work together.* At the same time, the submitted work must be the result of your own efforts. Indicate on the submitted work any individuals with whom you collaborated, whether receiving and/or providing help, and briefly for each individual the nature of that collaboration. *If you did not receive or give any help, state that fact as well.* Some journals (e.g., *Science, Nature*) require such statements on submitted manuscripts, so this requirement will help prepare you for submitting manuscripts to such journals.

2) **Presentation of one student-selected article** [*Career and Self-Development, Communication, Critical Thinking, Leadership, Professionalism, Teamwork*]

- In pairs (or threes, or alone), you will select and present to the class one article from the peer-reviewed scientific literature. The purpose of this assignment is to develop your skills in reading the scientific literature and in giving oral presentations. We will devote some time in the first weeks of class to discussing effective approaches for giving oral presentations.
- These articles must be related to the course topics covered during the two preceding weeks of class. So that we can post the articles at least one week before their presentation, please share with us the article you'd like to present not later than 10 days before they are scheduled to be presented. Journals such as *Science, Nature, Nature Astronomy, Nature Geosciences, Geophysical Research Letters, Geology, and PNAS* are fertile sources for appropriate and topical articles. Shorter topical articles from other journals are also appropriate.
- Presentations will be evaluated on the basis of a pre-defined rubric (available on the course Canvas site under *Article Presentation Materials*). As the pedagogical value of this assignment includes practicing collaboration, students working in groups will generally receive the same grade.

- Students not presenting will provide constructive feedback to the presenter(s) using this same evaluation form available on the Canvas site. In addition to providing feedback to the presenter(s), a second purpose for this assignment is to promote thoughtful engagement among the listeners. After each presentation, everyone will have ~5 minutes to complete the forms. We will collect these forms and provide them to the presenters along with our own evaluation. The grade will be based on our evaluation only, and any forms that contain any feedback that is non-constructive will not be passed to the presenters. These evaluations of fellow students are expected but not graded.

3) Write-ups of student-selected articles [*Career and Self-Development, Communication, Critical Thinking*]

- All students except the those presenting the article will – before the presentation – provide a write-up of the article. The purpose of this assignment is to further develop the fundamental skill of reading the scientific literature with understanding and thereby to support your writing of understandable scientific literature.
- Student-selected articles will be made available at least one week before they are scheduled to be presented, and write-ups of each article are due before class on the day it is scheduled to be presented.
- This write-up should be 1-2 pages in length and, in addition to the bibliographic information for the article, include five parts:
 - i) Background and motivation – Explain why this article was written, how the research was motivated by previous work, the knowledge gap(s) the article aims to address.
 - ii) Hypothesis to be tested – State the hypothesis (testable assertion) that the article aims to address.
 - a. Note that the hypothesis might be explicit or only implicit in the article
 - b. If you find yourself writing the hypothesis in question form, try to restate it as a testable assertion.
 - iii) Methods – Provide a brief description of the methods used
 - iv) The outcome of the hypothesis testing – Explain the results and whether they support the ingoing hypothesis or not. Describe the logical reasoning used to assess the results in the context of the hypothesis.
 - v) Explain something that you learned from the article and why this new knowledge is significant in the context either of the article topic or of our course material
 - vi) State something you didn't understand and where the confusion arose or something you weren't convinced by in the article and one or more ideas to further investigate it.

Examples are provided on the course Canvas site under *Article Presentation Materials*.

- Each of these six components will be worth 15% with the remaining 10% based on quality of the writing.
- Please sign up for a presentation topic and date by Friday, Jan 26. The sign up link is: https://docs.google.com/spreadsheets/d/1XJffD_-IFcfsn_OJHZ1VGiQpC-q4k5TtnZQKQIZxZ18/edit#gid=0

4) Final Exam: [*Career and Self-Development, Communication, Critical Thinking*]

A final exam will take place Wednesday, May 8, from 10 am to noon in our classroom. The exam will be based on the homework assignments, which might well have been completed in collaboration with classmates and for which the students will have received graded feedback. Thus, this exam provides the opportunity for each student to independently demonstrate assimilation and understanding of the course materials. The distribution of points will be indicated on each question.

Textbooks: This course does not require any textbook purchases. Useful references include:

- 1) Melosh, Planetary Surface Processes
- 2) Turcotte and Schubert, Geodynamics
- 3) Lissauer & de Pater, Planetary Science
- 4) Stacy and Davis, The Physics of the Earth
- 5) Anderson and Anderson, Geomorphology: the mechanics and chemistry of landscapes

Grading: Overall course grades will be determined using the following weights:

- Homework 60% [lowest grade will be dropped]
- Article Presentation 10%
- Article Write-ups 15% [lowest grade will be dropped]
- Final Exam 15%

Final letter grades will be assigned according to:

A = ≥ 89.50 , B = 79.5 – 89.5, C = 69.5 – 79.5, D = 59.5 – 69.5, F = < 59.5

Course Topics Outline: any needed adjustments will be promulgated by email and in class. No adjustments will move up (make earlier) the due date for any assignment.

WEEK	~ DATES	LIKELY TOPICS
1	Jan 17,19	Overview of the SS Review of the syllabus Shape of Solar System bodies
2	Jan 22,24,26	Gravity Current SS dynamics [Sign-ups for presentation topic and date due by Jan 26]
3	Jan 29,31, Feb 2	Orbital dynamics, Sources of comets and NEOs Asteroids [SBAG, Jan 30-Feb1] HW 1 due: Wed, Jan 31
4	Feb 5,7,9	Asteroids Meteorites
5	Feb 12,14,16	Impact Cratering Regolith on airless bodies HW 2 due: Wed, Feb 14
6	Feb 19,21,23	Regolith on airless bodies Space Weathering
7	Feb 26,28,	Interior structures: heating, differentiation and convection

	Mar 1	Deformation, topographic support Tectonism: Types of faults, fault morphologies on terrestrial and icy bodies and implications HW 3 due: Wed, Feb 28
8	Mar 4,6,8	Make-up week and/or topics TBD with student input
	Mar 11,13,15	[SPRING BREAK / LPSC] NO CLASS
9	Mar 18,20,22	Volcanism: Observations and theory for silicate volcanism and cryovolcanism. HW 4 due: Wed, Mar 20
10	Mar25,27,29	Slopes processes: mass movement, sublimation induced landforms
11	Apr 1,3,5	Aeolian processes and landscapes: mechanics and morphologies HW 5 due: Wed, Apr 3
12	Apr 8,10,12	Fluvial processes and landscapes: mechanics and morphologies
13	Apr 15,17,19	Ice: inner and outer Solar System HW 6 due: Wed, Apr 17
14	Apr 22,24,26	Rings, Kuiper Belt Objects
15	Apr 29, May 1,3	Make-up week and/or topics TBD with student input HW 7 due: Wed, May 1
	MAY 8, 10AM	FINAL EXAM in class

Article write-ups are due *before the start of class* on the day each article is presented.

Course Policies:

- As noted above, collaboration is a fundamental aspect of science and is encouraged on homework assignments, with appropriate credit. Conversely, plagiarism – defined by NAU as "using or representing another's original words, materials, or other creative output as one's own and not giving proper credit to the author or source" <https://in.nau.edu/wp-content/uploads/sites/90/2019/08/Academic-Integrity-Reporting-Form-2019.pdf> – is a breach of the principles of research and professional ethics. Any evidence for plagiarism would be discussed with the student(s) involved. If substantiated, plagiarism would result in a failing grade for the plagiarized work and, potentially, referral to the University. For NAU's policies on academic integrity, see <https://www9.nau.edu/policies/Client/Details/1443?wholsLooking=Students&pertainsTo=All>.
 - This course expects that any work submitted by students that contributes toward the course grade will be generated entirely by the students themselves. Thus, use of generative artificial intelligence tools, such as ChatGPT, would constitute an academic integrity violation.
- Homework and Article Write-ups are due by 11:30am – that is, *before* the start of class -- on their respective due dates. Homework is due in hard copy with pages stapled together. Article Write-ups are due electronically – either posted on Canvas or (if you run into problems posting) by email addressed to both of us.

- Each student may turn in one assignment of each type – one Homework and one Article Write-up – up to one week late without penalty for this lateness. No reason or prior notification is needed. Any subsequent late assignment(s) would not receive any credit, although we will grade such assignments to provide feedback on the work to facilitate studying for the final exam.
- If you must be unexpectedly absent on the day that you are scheduled to present your article, please let us know as soon as you are able. As our class that day will somewhat structured around your presentation, we ask you to make all reasonable efforts to fulfill this responsibility.
- Final Exam – If you cannot attend the final exam, please let us know as soon as possible. If you miss the exam without this prior notification, you will be able to make it up only under exceptional circumstances.

Standards of Attendance and Conduct: Please attend every class possible – *because research shows that in-person attendance and activities enhance learning* – and be fully present in class to support group learning as well as to maximize your own benefit from the course.

We also ask everyone to practice civility, including a genuine respect and valuing of others. NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, or veteran status. If you feel that the behavior of any class member – professor or student – is discriminatory, harassing, or otherwise impedes your learning, please bring it to our attention (if appropriate) so that we may together refer to the NAU resource(s) below and /or on the following pages for help in addressing this behavior.

- Equal Opportunity Office: <https://nau.edu/equity-and-access> or equityandaccess@nau.edu
- Title IX: <http://nau.edu/equity-and-access/title-ix> or pamela.heinonen@nau.edu
- Student Counseling Services: <https://in.nau.edu/campus-health-services/nau-counseling-services/>
- Office of the University Ombuds: <https://in.nau.edu/university-ombuds-program/>

Feedback: Feedback on this course is welcome, either something you like about the course and/or something we could do to enhance your learning. We'd be glad to receive information: (1) speaking in-person to one or both of us, and/or (2) sending one or both of us an email. Any feedback you provide, whether praiseworthy or critical, will not affect your grade. You're always free to join with other students in the class in communicating with us.

Students are always encouraged to avail themselves of procedures laid out in the [departmental graduate student handbook](#).

SYLLABUS POLICY STATEMENTS

ACADEMIC INTEGRITY

NAU expects every student to firmly adhere to a strong ethical code of academic integrity in all their scholarly pursuits. The primary attributes of academic integrity are honesty, trustworthiness, fairness, and responsibility. As a student, you are expected to submit original work while giving proper credit to other people's ideas or contributions. Acting with academic integrity means completing your assignments independently while truthfully acknowledging all sources of information, or collaboration with others when appropriate. When you submit your work, you are implicitly declaring that the work is your own. Academic integrity is expected not only during formal coursework, but in all your relationships or interactions that are connected to the educational enterprise. All forms of academic deceit such as plagiarism, cheating, collusion, falsification or fabrication of results or records, permitting your work to be submitted by another, or inappropriately recycling your own work from one class to another, constitute academic misconduct that may result in serious disciplinary consequences. All students and faculty members are responsible for reporting suspected instances of academic misconduct. All students are encouraged to complete NAU's online academic integrity workshop available in the E-Learning Center and should review the full *Academic Integrity* policy available at <https://policy.nau.edu/policy/policy.aspx?num=100601>.

ARTIFICIAL INTELLIGENCE

Artificial intelligence (AI) technologies bring both opportunities and challenges. Ensuring honesty in academic work creates a culture of integrity and expectations of ethical behavior. The use of these technologies can depend on the instructional setting, varying by faculty member, program, course, and assignment. Please refer to course policies, any additional course-specific guidelines in the syllabus, or communicate with the instructor to understand expectations. NAU recognizes the role that these technologies will play in the current and future careers of our graduates and expects students to practice responsible and ethical use of AI technologies to assist with learning within the confines of course policies.

COPYRIGHT INFRINGEMENT

All lectures and course materials, including but not limited to exams, quizzes, study outlines, and similar materials are protected by copyright. These materials may not be shared, uploaded, distributed, reproduced, or publicly displayed without the express written permission of NAU. Sharing materials on websites such as Course Hero, Chegg, or related websites is considered copyright infringement subject to United States Copyright Law and a violation of NAU Student Code of Conduct. For additional information on ABOR policies relating to course materials, please refer to [ABOR Policy 6-908 A\(2\)\(5\)](#).

COURSE TIME COMMITMENT

Pursuant to Arizona Board of Regents guidance (ABOR Policy 2-224, *Academic Credit*), each unit of credit requires a minimum of 45 hours of work by students, including but not limited to, class time, preparation, homework, and studying. For example, for a 3-credit course a student should expect to work at least 8.5 hours each week in a 16-week session and a minimum of 33 hours per week for a 3-credit course in a 4-week session.

DISRUPTIVE BEHAVIOR

Membership in NAU's academic community entails a special obligation to maintain class environments that are conducive to learning, whether instruction is taking place in the classroom, a laboratory or clinical setting, during course-related fieldwork, or online. Students have the obligation to engage in the educational process in a manner that does not interfere with normal class activities or violate the rights of

others. Instructors have the authority and responsibility to address disruptive behavior that interferes with student learning, which can include the involuntary withdrawal of a student from a course with a grade of "W". For additional information, see NAU's *Disruptive Behavior in an Instructional Setting* policy at <https://nau.edu/university-policy-library/disruptive-behavior>.

NONDISCRIMINATION AND ANTI-HARASSMENT

NAU prohibits discrimination and harassment based on sex, gender, gender identity, race, color, age, national origin, religion, sexual orientation, disability, veteran status and genetic information. Certain consensual amorous or sexual relationships between faculty and students are also prohibited as set forth in the *Consensual Romantic and Sexual Relationships* policy. The Equity and Access Office (EAO) responds to complaints regarding discrimination and harassment that fall under NAU's *Nondiscrimination and Anti-Harassment* policy. EAO also assists with religious accommodations. For additional information about nondiscrimination or anti-harassment or to file a complaint, contact EAO located in Old Main (building 10), Room 113, PO Box 4083, Flagstaff, AZ 86011, or by phone at 928-523-3312 (TTY: 928-523-1006), fax at 928-523-9977, email at equityandaccess@nau.edu, or visit the EAO website at <https://nau.edu/equity-and-access>.

TITLE IX

Title IX of the Education Amendments of 1972, as amended, protects individuals from discrimination based on sex in any educational program or activity operated by recipients of federal financial assistance. In accordance with Title IX, Northern Arizona University prohibits discrimination based on sex or gender in all its programs or activities. Sex discrimination includes sexual harassment, sexual assault, relationship violence, and stalking. NAU does not discriminate on the basis of sex in the education programs or activities that it operates, including in admission and employment. NAU is committed to providing an environment free from discrimination based on sex or gender and provides a number of supportive measures that assist students, faculty, and staff.

One may direct inquiries concerning the application of Title IX to either or both the Title IX Coordinator or the U.S. Department of Education, Assistant Secretary, Office of Civil Rights. You may contact the Title IX Coordinator in the Office for the Resolution of Sexual Misconduct by phone at 928-523-5434, by fax at 928-523-0640, or by email at titleix@nau.edu. In furtherance of its Title IX obligations, NAU promptly will investigate or equitably resolve all reports of sex or gender-based discrimination, harassment, or sexual misconduct and will eliminate any hostile environment as defined by law. The Office for the Resolution of Sexual Misconduct (ORSM): Title IX Institutional Compliance, Prevention & Response addresses matters that fall under the university's Sexual Misconduct policy. Additional important information and related resources, including how to request immediate help or confidential support following an act of sexual violence, is available at <https://in.nau.edu/title-ix>.

ACCESSIBILITY

Professional disability specialists are available at Disability Resources to facilitate a range of academic support services and accommodations for students with disabilities. If you have a documented disability, you can request assistance by contacting Disability Resources at 928-523-8773 (voice), 928-523-8747 (fax), or dr@nau.edu (e-mail). Once eligibility has been determined, students register with Disability Resources every semester to activate their approved accommodations. Although a student may request an accommodation at any time, it is best to initiate the application process at least four weeks before a student wishes to receive an accommodation. Students may begin the accommodation process by submitting a self-identification form online at <https://nau.edu/disability-resources/student-eligibility-process> or by contacting Disability Resources. The Director of Disability Resources, Jamie Axelrod, serves as NAU's Americans with Disabilities Act Coordinator and Section 504 Compliance Officer. He can be reached at jamie.axelrod@nau.edu.

RESPONSIBLE CONDUCT OF RESEARCH

Students who engage in research at NAU must receive appropriate Responsible Conduct of Research (RCR) training. This instruction is designed to help ensure proper awareness and application of well-established professional norms and ethical principles related to the performance of all scientific research

activities. More information regarding RCR training is available at <https://nau.edu/research/compliance/research-integrity>.

MISCONDUCT IN RESEARCH

As noted, NAU expects every student to firmly adhere to a strong code of academic integrity in all their scholarly pursuits. This includes avoiding fabrication, falsification, or plagiarism when conducting research or reporting research results. Engaging in research misconduct may result in serious disciplinary consequences. Students must also report any suspected or actual instances of research misconduct of which they become aware. Allegations of research misconduct should be reported to your instructor or the University's Research Integrity Officer, Dr. David Faguy, who can be reached at david.faguy@nau.edu or 928-523-6117. More information about misconduct in research is available at <https://nau.edu/university-policy-library/misconduct-in-research>.

SENSITIVE COURSE MATERIALS

University education aims to expand student understanding and awareness. Thus, it necessarily involves engagement with a wide range of information, ideas, and creative representations. In their college studies, students can expect to encounter and to critically appraise materials that may differ from and perhaps challenge familiar understandings, ideas, and beliefs. Students are encouraged to discuss these matters with faculty.

Last revised November 28, 2023