Principles of Planetary Physics
Planetary Sciences 505A
Fall 2026
Kuiper 312, TTh 12:30-13:45

Instructor: Prof. Kristopher G. Klein, Kuiper Space Sciences 431; kgklein@arizona.edu
Office Hours: Monday: 3:00-4:00pm; Thursday: 3:00 - 4:00pm (or by arrangement)
This class is scheduled to be taught in the in person modality.

This course will use a D2L website for assignments, lecture notes, and communications. Email communications with Prof. Klein should include **PTYS 505A** in the subject line and be from your UA email address; I will endeavor to respond to emails within one business day.

As this is a three credit course, there is an expectation of 90 hours of reading, homework, and other studies to be done by the student outside of lecture.

Students will be expected to be familiar with vector calculus and both ordinary and partial differential equations. In addition, students will be expected to know, or learn, a programming language such as C, Fortran, IDL, MATLAB, or python. **Course requisites:** Classical and quantum mechanics at the level of PHYS 151 and PHYS 242.

Course Objectives

This is a one-semester survey of physical properties relevant to planetary sciences.

This course presents an introduction to the physics of planetary and interplanetary gases, fluids and plasmas. The semester will be divided into studies of Thermodynamics, Kinetic Theory, Hydrodynamics, and Plasma Physics, all with a focus on solar-system applications. Specific topics are listed in the preliminary course schedule. The course will emphasize the use of physical models, mathematical derivations, order-of-magnitude reasoning, and solar-system applications to understand gases, fluids, and plasmas in planetary science.

This course is a complement to PTYS505B, which covers the physical processes controlling planet formation, the orbital and rotational dynamics of planetary systems, the mechanical and thermal aspects of a planetary interior, and the dynamics of the Earth-Moon and other satellite systems.

During the course, students will learn about:

- Thermodynamics
- Kinetic Theory
- Radiation
- Hydrodynamics
- Plasma Physics
- Magnetohydrodynamics and Dynamo Theory
- Planetary Magnetic Fields and Solar Wind Interactions

Expected Learning Outcomes

Upon completion of this course, students will be able to:

- Describe key kinetic, hydrodynamic, thermodynamic, radiative, and plasma processes relevant to space and planetary systems.
- Apply physical models, mathematical derivations, and order-of-magnitude reasoning to planetary and heliospheric systems.
- Communicate a selected planetary-physics topic in written and oral form through a set of lecture notes and a presentation.
- Analyze specific physical systems relevant to their area of focused research using concepts developed in the course.

Generative Artificial Intelligence Policy

Generative artificial intelligence systems are tools, the same as the processor and computer used to write this syllabus instead of the professor's handwriting. Tools may be used in limited ways in this course, but they **must** not replace the student's own reasoning and ability to explain the underlying physics.

For homework assignments, students may use AI tools as a study aid in the same way they might use a textbook, office hours, or discussion with classmates: to review background concepts, ask for clarification of general ideas, or check syntax in computational work. The final submitted homework must represent the student's own understanding, and the student may be asked about any element of their submitted work.

For the oral exams, no generative AI tools, internet-connected tools, cell phones, or laptops may be used, only a chalkboard and page of notes, and the NRL Plasma formulary.

For the final project, students may use AI tools for process support, such as brainstorming search terms, improving grammar, organizing an outline, or identifying areas where additional explanation may be needed. Scientific writing is not simply the act of putting one word after another, but a process of focused thinking where the author is continually confronted with decisions which shape the author's understanding of the material. Don't let a tool rob you of developing this skill.

Any use of AI in the final project must be acknowledged in a short note describing which tool was used and how it was used. Students remain responsible for verifying all facts, references, equations, interpretations, and citations. In this class, and in your research **AI-generated references must be independently checked**, since these tools can produce plausible but nonexistent sources; including references in real papers to fake papers by real authors.

In general, students should not enter confidential, private, or sensitive information into AI systems. If you are unsure whether a particular use of AI is appropriate for an assignment, please ask Prof. Klein before submitting the work.

Texts and Course Materials

The course will draw from a number of texts and references, but the necessary elements will be included in the class notes, which will be posted on D2L and *continuously* updated throughout the semester.

Homework

There will be approx. bi-weekly homework assignments throughout the semester. Assignments will be posted in advance on the D2L website. The up-to-date class schedule can also be found here. Each homework will have at least one week for completion from posting, then they will be graded and returned to you within a week. You may discuss the homework with other students, but be sure the final work is yours. Do not let others copy your homework; it could result in your getting flagged for plagiarism, and **you receiving a zero for the assignment.**

Late Homework

Late homework will not be accepted except in very exceptional cases. For scheduled absences like religious holidays and university travel, the homework can be downloaded from D2L in advance so that it can be turned in early. In cases of a sudden family or medical emergency, late homework may be accepted, but only before the graded homework is returned and solutions posted.

Exams

There will be two midterm exams, each covering approximately half of the course material. The dates of the exams are listed on the class schedule; please alert me at least two weeks in advance if you have an approved conflict.

The midterms will be oral exams. Details on the format will be provided at least two weeks prior to the set exam date.

No cellphones or laptops are allowed during the examination. A single page sheet of notes produced by the student and the NRL plasma formulary will be allowed for reference during the exam.

Missed Exams

If you need to miss an exam for a University-approved reason, contact Dr. Klein as soon as possible. If you know that you will need to be absent or will miss course deadlines, you are expected to make every effort to inform us before it occurs so that we can make arrangements in advance. Note that illness will require documentation as described in the Absence and Class Participation Policy below. Skipping the exam without a University-approved excuse or proper documentation of your absence will result in a zero grade.

Final Project

This course will have a final project that will involve selecting a fundamental physical process not covered in detail in the class, researching this topic, preparing a set of lecture notes, and presenting the lecture, either in video recording or in class (depending on this semester's enrollment).

There will be due dates throughout the semester for selecting and proposing a topic, turning in a draft for feedback and the opportunity to revise and resubmit, and final submission of the project. Details on this project are posted on D2L.

Lectures and Class Participation

Most lectures will be presented in person by Prof. Klein, although occasionally a guest lecturer may lead the class, or a lecture will be delivered remotely via zoom. The lecture notes and associated readings will be placed on D2L before the class. Lectures will be interactive, including participation in the form of questions, class discussion, and board work.

Grading Scale & Policies

The overall grade associated with this course will have the following weights:

Midterm Exams: $2 \times 15\%$	Homework: 50%	Project: 20%

Final Letter Grades will be assigned as follows, and will be calculated to the nearest 0.1%. A curve may be considered, depending on the observed distribution of scores at the end of the semester.

A: $\geq 90\%$	B: $\geq 80\%$	C: $\geq 70\%$	D: $\geq 60\%$	E: $< 60\%$

Homework will be evaluated based on the correctness of the physical reasoning, mathematical derivations, calculations, clarity of explanation, and appropriate use of units and approximations. The final project will be evaluated based on a provided rubric, focusing on physical accuracy, clarity, organization, appropriate use of sources, and effectiveness of the written notes and oral presentation. University policy regarding grades and grading systems is available here. Requests for incomplete

(I) or withdrawal (W) must be made in accordance with University policies, which are available here and here respectively.

Makeup Policy for Late Registering Students

Students who register by the end of the second week of class may be given an opportunity to make up missed assignments within a reasonable amount of time, to be mutually agreed upon by the student and instructor.

Approximation Scheme

If you have read to this point in the syllabus, and alert Prof. Klein to at least *three* unique typographical errors in the class notes, your grade will be rounded up to the next highest 1%. This is the only extra-credit opportunity offered in this class.

Regrades

All your work will be graded by Prof. Klein. Although I will make every effort to evaluate your work thoroughly and fairly, I am only human. If you think there is an error in grading your homework, please contact me; I will look at your work again and return it to you with a response, usually within a week. **You must report any grading errors within a week of the return of your assignment/exam to receive a regrade.**

Questions & Concerns

It is very important that you let the instructor know about any concerns about any aspect of the class as soon as they arise. There are many ways to contact us about questions or concerns about the course material and your grade. Weekly office hours are the best place to ask questions and get help. You are also welcome to talk to me after class, or you can make an appointment to meet with me outside of office hours if that works better.

Approx. Course Schedule & Due Dates

The schedule for this course can be found at this link. The schedule may be updated throughout the semester, with significant updates announced in class and over D2L.

Week	Date	Topic 1	Topic 2
Thermodynamics			
1	08/25/2026	Thermodynamics	Maxwell's Relations/ Ideal Gases
Kinetic Theory			
2	09/01/2026	Kinetic Theory	Stochastic Processes and Collisions
Radiation			
3	09/10/2026	Cavity Radiation	Radiation Pressure
4	09/17/2026	Radiative Transfer	Rad. Trans. Cont.
Fluid Dynamics			
5	09/24/2026	**Midterm**	Fluids
6	10/01/2026	Potential Flows	Potential Fields
7	10/08/2026	Waves	Hydrodynamic Stability
8	10/15/2026	Turbulence	What is a Plasma
Plasmas			
9	10/22/2026	Single Particle Motion	Drifts and Invariants
10	10/29/2026	Plasma Waves	MHD
MHD			
11	11/03/2026	MHD Convection and Diffusion	MHD Waves
Plasma Processes			
12	11/10/2026	Disks	**Midterm**
13	11/17/2026	Dynamos	Shocks
14	11/24/2026	Solar Wind	Earth's Magnetosphere
15	12/01/2026	Project Presentations	cont.
16	12/08/2026	Other Magnetospheres	—

University Policies
All UA Academic policies can be found here.

Classroom Attendance
If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel. Notify your instructor if you will be missing a course meeting or an assignment deadline. Non-attendance for any reason does not guarantee an automatic extension of due date or rescheduling of examinations/assessments. Please communicate and coordinate any request directly with your instructor. If you must miss the equivalent of more than one week of class, you should contact the Dean of Students Office (`DOS-deanofstudents@email.arizona.edu`) to share documentation about the challenges you are facing.

Academic Advising
If you have questions about your academic progress this semester, please reach out to your academic advisor (`https://advising.arizona.edu/advisors/major`). Contact the Advising Resource Center (`https://advising.arizona.edu/`) for all general advising questions and referral assistance. Call 520-626-8667 or email to `advising@arizona.edu`

Life Challenges
If you are experiencing unexpected barriers to your success in your courses, please note the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office can be reached at (520) 621-2057 or `DOS-deanofstudents@email.arizona.edu`.

Physical and mental-health challenges
If you are facing physical or mental health challenges this semester, please note that Campus Health provides quality medical and mental health care. For medical appointments, call (520) 621-9202. For After Hours care, call (520) 570-7898. For the Counseling & Psych Services (CAPS) 24/7 hotline, call (520) 621-3334.

Safety on Campus and in the Classroom
For a list of emergency procedures for all types of incidents, please visit the website of the Critical Incident Response Team (CIRT): `https://cirt.arizona.edu/case-emergency/overview`

Also watch the video available here

Classroom Behavior Policy
We all have a shared responsibility to create a positive learning environment free from distractions. If you arrive late to class or need to leave early, please choose a seat on the aisle and enter/exit quietly. Please silence your phone during class. If you need to accept an emergency phone call, exit the lecture hall fully before talking on the phone. Behaviors that could be disruptive to other students are not acceptable and disruptive students will be asked to leave. Examples of potentially disruptive behaviors include making phone calls, web surfing, watching videos, or reading a newspaper.

Department policy *forbids any outside food or drink, except water, in the lecture hall.*

The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself.

UA Academic policies and procedures are available here. Student Assistance and Advocacy information is available here.

Accessibility & Accommodations

Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please contact Dr. Klein and the Disability Resource Center (520-621-3268) so that reasonable accommodations can be arranged. Additional information on reasonable accommodations can be found at the Disability Resource Center.

Code of Academic Integrity

Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work and exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog.

Students who plagiarize will get a zero for the assignment.

If you have questions about how to cite sources or plagiarism, please talk to the instructor. The UA libraries also provide references on the distinction between citation and plagiarism.

UA Nondiscrimination and Anti-Harassment Policy

The University is committed to creating and maintaining an environment free of discrimination. The classroom is a place all are encouraged to ask questions and express well-formed opinions and their reasons for those opinions. We want to create a tolerant and open environment where comments and questions can be expressed without resorting to bullying or discrimination of others.

Confidentiality of Student Records

Student records, including grades, will be handled according to FERPA guidelines.
Please contact Dr. Klein yourself if you have questions about grades.

Subject to Change Statement

All information presented in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

University-Wide Policies

Policies established by UA regarding *Absence and Class Participation*, *Threatening Behavior*, *Accessibility and Accommodations*, *Code of Academic Integrity*, and *Nondiscrimination and Anti-Harassment* can be found at the Academic Affairs website.