

**The Physics of the Sun**  
Planetary Sciences 537 (PTYS/ASTR/ATMO/PHYS 537)  
Graduate Elective Course  
Kuiper 312, MWF 1:00-1:55 pm

**Instructor:**

Dr. Kristopher G. Klein, Kuiper Space Sciences 431; kgklein@lpl.arizona.edu

*Office Hours:* Tuesday: 3-4pm; Thursday: 11am - noon (or by arrangement)

**Office Hours will be held virtually via zoom**

This course will use a D2L website for assignments, lecture notes, and communications. Assignments and exams will be submitted through the website. Email communications with Prof. Klein should include **PTYS 537** and the student's name in the subject line and be from your UA email address; we 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.

## Course and Learning Objectives

The purpose of this course is to present an introduction to the physics of the Sun. Topics will include the physics of solar magnetic fields, solar interior and helioseismology, radiative transfer, solar wind, and solar-energetic particles. This course will introduce the equations of magnetohydrodynamics and apply them to important solar-physics problems. Examples include: the solar dynamo, the physics of sunspots and flares, origin of the solar wind, and the structure of the solar atmosphere. The emphasis throughout will be on basic physical processes and the various approximations used in their application to realistic and relevant problems. Identical to ASTR/ATMO/PHYS 537. PTYS is home department.

**During the course, students will learn about:**

- *Fundamental Plasma Physics*, wherein a necessarily brief introduction to the basic behavior of the Sun's constituent state of matter is provided,
- *The Sun & Its Structures*, where our current state of knowledge about the layers of the Sun and its atmosphere, as well as the methods used to derive said knowledge, is described, and
- *The Dynamics of the Sun & Its Extended Atmosphere*, where a plethora of processes germane to solar dynamics, ranging from magnetic reconnection to the dynamo are elucidated.

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

- Clearly communicate solar physics concepts, articulating open questions in the study of the Sun.
- Solve using appropriate mathematical tool problems relevant to Solar and Heliospheric systems.
- Describe the various approximations used in modeling the Sun, and identify under what conditions such approximations are appropriate.

## Texts and Course Materials

The course will trace the trajectories laid out in Kulsrud's *Plasma Physics for Astrophysics* and Priest's *Magnetohydrodynamics of the Sun*, with supplemental material from other plasma physics and astrophysics texts as well as research papers from the literature.

## Homework

There will be approx. weekly homework assignments throughout the semester, except for the weeks for which there is an exam or project due, and they will be posted in advance on the D2L website.

The homework will be a combination of mathematical manipulations and written short responses. Each homework will have at least one week for completion from posting, then they will be graded and returned to you within a week. Homework must be turned in on D2L **in pdf format**, where it will automatically be checked for plagiarism. 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**

No late homework will 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, and there is no reason for a due-date extension. In cases of a sudden family or medical emergency, late homework may be accepted, but only before the graded homework is returned.

### **Exams**

There will be three exams, open book format, roughly mapping to the three parts of the course. The dates of the exam postings are listed below; please consult with Prof. Klein if any conflicts with these dates are identified.

There will be no final exam for this course, but rather a final project, detailed below.

### **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. 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 presentation project that will involve researching material related to the course and applying this information to produce a fifteen minute presentation and associated set of lecture notes.

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 notes and presentation.

### **Lectures and Class Participation**

Most lectures will be presented by Dr. Klein, although occasionally a guest lecturer may lead the class. The lecture notes will be placed on D2L in the form of the continually updated *PTYS537\_2020.pdf* before each class so they can be downloaded in advance. Lectures will include participation in the form of questions, class discussion, and/or short writing assignments.

### **Grading Scale & Policies**

The Course Components will have the following weights:

3 Exams: 60% total	Homework: 20%	Final Project : 20%
--------------------	---------------	---------------------

Final Letter Grades will be assigned as follows, and will be calculated to the nearest 0.1%.

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

These limits may be curved downwards based upon the final distribution of scores, but will not be curved to values above these thresholds.

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.

## Regrades

All your work will be graded by Dr. Klein. Although we will make every effort to evaluate your work thoroughly and fairly, we are only human. If you think there is an error in grading your homework or exam please contact Dr. Klein. We 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 your concerns about any aspect of the class as soon as they arise, and we are happy to help you. 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.

## Class Participation and Absence Policy

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is encouraged at all lectures.

- We follow the UA's policy on Class Attendance, Participation, and Administrative Drops.
- We follow the UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable.
- Absences pre-approved by the UA Dean of Students (or Dean Designee) will be honored.

## 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 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.

**Student who plagiarize will get a zero for the assignment.**

## **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.

## Approx. Course Schedule & Due Dates

Week	Date	Topic	Due
<b>Part One: Fundamental Plasma Physics</b>			
1	8/24/2020	Our Star, the Sun	—
2	8/31/2020	Single Particle Motion	HW#1
3	9/09/2020	Moment and Fluid Equations	HW#2
4	9/14/2020	MHD	Project Proposal
5	9/21/2020	MHD Waves	HW#3
6	9/28/2020	Waves in non-uniform media	Exam #1
7	10/05/2020	MHD Stability	HW#4
8	10/12/2020	Parker, RT, & MRI Stability	HW#5
<b>Part Two: The Sun &amp; Its Structures</b>			
9	10/19/2020	Layers of the Sun	Project Draft
10	10/26/2020	Helioseismology	HW#6
11	11/02/2020	The Solar Wind and Extended Atmosphere	Exam # 2
<b>Part Three: The Dynamics of the Sun &amp; Its Extended Atmosphere</b>			
12	11/09/2020	Magnetic Reconnection	HW#7
13	11/16/2020	Coronal Mass Ejections	HW#8
14	11/23/2020	Turbulence & Thanksgiving	HW#9
15	11/30/2020	Solar Dynamo	Exam #3
16	12/07/2020	Sunspots, Flares, and Missions to Explore the Heliosphere	Final Project

## COVID-19 and Course Modality

Given the unusual circumstances imposed by the SARS-COV-2 virus and the associated COVID-19 pandemic, there are a number of unique considerations for this offering of PTYS 537.

Through out the semester, all of the lectures for this course will be broadcast live via zoom.

The lectures will also be recorded, using zoom, with links to these recordings made available on D2L so that if a student is unable to attend the 'live' lecture, they may review the recordings.

For those on campus who are able to safely come to class, and when the campus is in 'Stage Two: Essential In-Person / Outdoor / Small In-Person courses on our campuses' I will be broadcasting the lectures from Kuiper 308. Given the size of this lecture hall, and the enrollment of the course, there is more than sufficient space to enable appropriate social distancing, and we all will be taking the necessary precautions— wearing a mask, washing hands regularly, keeping at least 6 feet apart. If you are unable to, for whatever reason, attend these in-person lectures, there will be no penalty against your grade.

I realize these are difficult times, so if you have any questions, or the need for additional reasonable accommodations arise, please do not hesitate to reach out to me at my UArizona email.

What follows is the current version of the UArizona boilerplate as of August 11, 2020:

This class is scheduled to be taught in the IN-PERSON modality.

**Meeting Times:** We will be meeting remotely until the University notifies us that in-person meetings may commence. We will meet MWF 1:00-1:55 pm by Zoom, at the coördinates <https://arizona.zoom.us/j/91838328559> When the COVID-19 situation permits teaching on campus, we will be meeting MWF 1:00-1:55 pm in Kuiper 312, though the lectures will still be broadcast via zoom, at the same link as above.

Face coverings are required in our classroom: Per UArizona's Administrative Directive, face coverings that cover the nose, mouth, and chin are required to be worn in all learning spaces at the University of Arizona (e.g., in classrooms, laboratories and studios). Any student who violates this directive will be asked to immediately leave the learning space, and will be allowed to return only when they are wearing a face covering. Subsequent episodes of noncompliance will result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied. The student will not be able to return to the learning space until the matter is resolved.

The Disability Resource Center is available to explore face coverings and accessibility considerations if you believe that your disability or medical condition precludes you from utilizing any face covering or mask option. DRC will explore the range of potential options as well as remote course offerings. Should DRC determine an accommodation to this directive is reasonable, DRC will communicate this accommodation with your instructor.

Physical distancing is required in our classroom: During our in-person class meetings, we will respect CDC guidelines, including restricted seating to increase physical distancing. Any student who does not maintain physical distance from others may be asked to immediately leave the learning space. Noncompliance may result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied.

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 instructors if you will be missing an in person or online course.
- Campus Health is testing for COVID-19. Please call (520) 621-9202 before you visit in person.

- Visit the UArizona COVID-19 page for regular updates.

**Academic advising:** If you have questions about your academic progress this semester, or your chosen degree program, please note that advisors at the Advising Resource Center can guide you toward university resources to help you succeed.

**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.

**Exams:** Exams will be take home, will be made available on D2L on a specified day, with solutions needing to be uploaded as a pdf within a specified number of hours. There will be no final exam, but rather a final project combining a presentation and set of lecture notes that will have due dates spread throughout the semester.

**Equipment and software requirements:** For this class you will need daily access to the following hardware: computer or web-enabled device with video camera and microphone; regular access to reliable internet signal; ability to download and run the following software: zoom, a web browser; ability to upload pdfs.

**Staying current:** You are required to complete (describe which activities, with what deadlines) on your own time to accomplish (enumerate course goals).

**Remain flexible:** If pandemic conditions warrant, the University may require that we return to remote operations. If that is the case, we will notify you by D2L Announcement and email that we are moving to remote operations.

**Remote / online only after Thanksgiving:** After the Thanksgiving holiday, we are scheduled to move to remote teaching. We will continue to meet MWF 1:00-1:55 pm by Zoom.

**Class Recordings:** Recordings of the lectures and associated zoom content will be captured and made accessible to your fellow students.

If you do not wish to be identified by name in these recordings, please see [FERPA](#) Privacy Protection guide.

For lecture recordings, which are used at the discretion of the instructor, students must access content in D2L only. Students may not modify content or re-use content for any purpose other than personal educational reasons. All recordings are subject to government and university regulations. Therefore, students accessing unauthorized recordings or using them in a manner inconsistent with UArizona values and educational policies are subject to suspension or civil action.