

## ASTR-3760: Solar and Space Physics

CU Boulder Course Syllabus (Spring 2017)

- Instructor:** Prof. Steven R. Cranmer (steven.cranmer@colorado.edu, 303-735-1265)  
**Office:** Duane Physics D-111, or LASP SPSC N-218 (east campus)  
**Course Times:** Mon., Wed., Fri., 9:00–9:50 am  
**Location:** Duane Physics, Room G-131  
**Course web page:** [http://lasp.colorado.edu/~cranmer/ASTR\\_3760\\_2017/](http://lasp.colorado.edu/~cranmer/ASTR_3760_2017/)  
**Office hours:** Duane D-111: Mondays & Fridays 10:00–11:00, or by appointment

### SUMMARY

We live in the extended atmosphere of a magnetic variable star. Solar radiation enables and sustains life, but the Sun also produces streams of high energy particles and radiation that can be harmful to people and their technology. In this course we will explore the physical processes that link the Sun to the planets, and we will learn about the behavior of the tenuous, magnetized plasma that fills the rest of the solar system. Topics discussed in this course will include some basic plasma physics, the solar interior and atmosphere, the solar wind and coronal mass ejections, planetary magnetospheres, and space weather. Roughly half of the course can be considered “*the Sun as an example of stellar astrophysics,*” and the other half is “*Space plasma physics for astronomers.*”

This course is an elective for the APS undergraduate major and minor. Pre-requisite (or co-requisite) courses include Modern Physics (PHYS-2130 or PHYS-2170), and Calculus 3 (MATH-2400 or APPM-2350). A recommended, but not required, pre-requisite is Electricity & Magnetism (PHYS-3310).

### COURSE GOALS

At the end of the course, you should be able to:

- Define what a plasma is, and describe (mathematically) the basic properties of some important plasmas in our solar system.
- Employ order-of-magnitude physical reasoning to describe how energy flows from the core of the Sun to the surface of the Earth.
- Discuss how measurements in solar physics and space plasma physics are carried out.
- Describe to interested laypeople and family members what we can learn from solar & space physics, and how it affects our everyday life.

### COURSE MATERIAL

You won't be required to purchase a textbook for this course. The main material for the course will be contained in PDF lecture notes (which I will use for lecturing, too) to be linked on the course [web page](#).

In class, I will also distribute reading material extracted from books, articles, and lecture notes from other courses. You will need to read this material for some of the homework sets, but not for the exam. The course web page will also contain links to longer sets of online reading material that you can use as background research for the final project.

## GRADING

The final grade will be assembled from the following components:

6 Homework Sets .....	12 points (2 each)	
Midterm Exam .....	7 points	
Final Project/Paper .....	5 points	
In-Class Engagement .....	1 point	
<b>Total</b> .....	25 points	→ drop lowest: <b>24 points = 100%</b>

Each of these components is described in more detail below. Note the total grade comes to 25 out of 24 “points.” To produce the final grade, I will drop the lowest-grade point from either the homework sets, midterm exam, or final project. (The score for in-class engagement is not droppable.)

## SCHEDULE OF TOPICS

The dates listed below are approximate. See the [web page](#) for the most up-to-date schedule.

<b>I. Introduction &amp; Overview</b> .....	<b>7 lectures</b>
• Syllabus review & why is this course awesome?	1/18
• Reviews of vector calculus, E&M, energy concepts	1/20, 1/23, 1/25
• Survey of various ways we observe the Sun	1/27, 1/30
• Movie day at Fiske Planetarium	2/8
<b>II. Magnetized Plasmas</b> .....	<b>6 lectures</b>
• Kinetic theory & thermodynamics	2/1, 2/3, 2/6
• Behavior of MHD fluids	2/10, 2/13, 2/15
<b>III. Solar Interior</b> .....	<b>8 lectures</b>
• Total stellar energy content	2/17
• Nuclear energy generation	2/20, 2/22
• Radiative & convective energy transport	2/24, 2/27, 3/1
• Helioseismology & solar dynamo	3/3, 3/6
<b>IV. Solar Atmosphere</b> .....	<b>7 lectures</b>
• Photosphere: emergent spectrum	3/8, 3/10, 3/13
• How does solar radiation heat Earth & other planets?	3/15
• Photosphere: sunspots & magnetic field	3/17, 3/24, 4/3
<b>V. Solar Activity</b> .....	<b>6 lectures</b>
• Chromospheric & coronal heating	4/5, 4/7, 4/10
• The solar wind & heliosphere	4/12, 4/14, 4/17
<b>VI. Space Physics</b> .....	<b>8 lectures</b>
• Coronal Mass Ejections & reconnection	4/19, 4/21, 4/24, 4/26
• Magnetospheres	4/28, 5/1
• Ionospheres & space weather	5/3, 5/5

## **HOMEWORK SETS**

There will be approximately six homework assignments distributed throughout the semester. A detailed schedule of distribution and due dates will be posted on the course web page. All but one of them will be mostly mathematical “problem sets.” The remaining one (probably #3) will be a mini-project to find a popular news article on a topic relevant to this course, and critique it. Requirements for this written critique will be handed out later.

Hardcopy submissions are preferred, but email is fine, too. Students choosing the latter option are encouraged to write out solutions long-hand (neatly!) and scan them. This way you won’t be tempted to leave out intermediate steps when typing in equations.

Homeworks are due at the beginning of class on the dates to be given. However, since it is our top priority that you have sufficient time to learn from the homework sets, each student can arrange *one* late submission if they need: One homework set can be turned in up to three business days late with no penalty. (However, you must inform me that you’ll be taking this option at least *one class session prior to the due date.*) Any other homework that is late will incur a penalty of a 5% lower grade per business day that it is late.

## **MIDTERM EXAM**

This will be more like a “two thirds of the way through the semester” exam, to be given in the week before Spring Break. Prior to the exam, there will be at least one full class session devoted to reviewing the relevant material. Details about its format will be forthcoming.

## **FINAL PROJECT/PAPER**

In lieu of a sit-down final exam, there will be a project that will enable you to explore a chosen topic in a bit more detail and gain some extra experience with scientific writing. There are several paths you could take:

1. The typical project would be just a paper: a written review of a topic relevant to the course, that goes significantly beyond the material discussed in class. The paper must convey some background (i.e., how did we come to understand the topic), motivation (i.e., why is it relevant), and some quantitative exploration of the physics (i.e., some relevant equations). The length to aim for is about 10 to 12 double-spaced pages—i.e., about 2500–3000 words—not counting snazzy figures (recommended) and a bibliography of cited sources (required).
2. If you have an idea to do some kind of mathematical or computational calculation that explores a topic relevant to the course, please let your instructor know about it. You may want to construct your own model or simulation, or even download some publicly available data to analyze. You would still need to write a paper describing what you did, but it can be filled mainly with the results and not as much “deep background” as in option 1. (*Instructor approval is needed.*)
3. If you have an idea for a unique bit of public outreach (i.e., a video, animation, game, or art project) that would get the general public engaged about the importance of solar & space physics, please let your instructor know about it. As above, you would still need to write a paper describing your motivations, thought processes, and source material, but it can be short (4–5 pages) if submitted along-side the main product. (*Instructor approval is needed.*)

Additional information, including lists of possible topic ideas and deadlines, will be distributed during the semester.

## **IN-CLASS ENGAGEMENT**

Attendance is important, because not everything will be included in the online lecture notes. The grade for in-class engagement is essentially “did it” or “didn’t do it.” In other words, all you need to get your 1 point (toward the total grade) is to attend class regularly and show consistent engagement with the material. This can be demonstrated through asking questions in class, answering questions that someone else has raised, attending office hours, and/or participating actively in the any break-out sessions we may hold.

## **ACADEMIC INTEGRITY**

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the [academic integrity policy](#) of the institution. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council ([honor@colorado.edu](mailto:honor@colorado.edu); 303-735-2273). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at [honorcode.colorado.edu](http://honorcode.colorado.edu).

For this course, I encourage you to discuss the assignments and topics with your fellow students. However, everything that is written up and submitted must be your own independent work. If you do collaborate with other students, a good time to split off from the group is when you start to write up your answers. If someone were to ask you questions about your work, you should be able to explain everything about how & why you did it the way you did.

## **STUDENTS WITH DISABILITIES**

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations, provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu). If you have a temporary medical condition or injury, see the [Temporary Injuries](#) guidelines under the Quick Links at the [Disability Services website](#) and discuss your needs with your professor.

## **RELIGIOUS OBSERVANCES**

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. If you have religious obligations that result in schedule conflicts, please contact me in the first two weeks of class to make alternate arrangements. For full details, see the [campus policy](#) regarding religious observances.

## **DISCRIMINATION AND HARASSMENT**

The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, discrimination, harassment, or related retaliation against or by any employee or student. CU’s Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking, or related retaliation. CU Boulder’s Discrimination and Harassment Policy prohibits discrimination, harassment or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed,

religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation, or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist individuals regarding sexual misconduct, discrimination, harassment or related retaliation can be found at the [OIEC website](#).

## **CLASSROOM BEHAVIOR**

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, color, culture, religion, creed, politics, veteran status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. For more information, see the [policies on classroom behavior](#) and the [student conduct code](#).

The policy of the Department of Astrophysical and Planetary Sciences is to ban any use of electronic devices (cellphones, tablets, laptops) in class except as an approved accommodation granted by Disability Services, or as explicitly authorized by the instructor. *In this course* I authorize the use of tablets and laptops for note-taking, but students doing so must do their best to seat themselves with nobody behind them.

