Course Title: Introduction to Space Physics
Course Number: ERTH 423M/523M / PHYS 423M/523M

Instructor Information:
Prof. Carol Paty
Email: cpaty@uoregon.edu
Office Hours: Thursday 10-11:50am in Volcanology 120 (or via Zoom)

TA: Katelin Donaldson
Email: katelind@uoregon.edu
TA Office Hours: TBD in Volcanology 103 (or via Zoom)

Class Information: Monday/Wednesday: 2:00 pm – 3:20 pm – Friendly 106

Course Materials
Basic Space Plasma Physics (2022 edition) by W. Baumjohann & R. Treumann
*Supporting texts and papers that may be useful will be provided digitally.

Course Description
This course will explore the interaction of the solar wind with the Earth’s magnetosphere using fundamental plasma physics supported and motivated by spacecraft observations. Students will gain an understanding of the physics governing the interaction of the solar wind and the Earth’s magnetosphere building from single particle plasma motion to specific observation supported examples.

Topics Covered
The Scope of Space Physics
Introduction to Space Plasmas:
Characterization
Single Particle Motion
Kinetic Plasma Theory
Magnetohydrodynamics (MHD)
Magnetic Reconnection
Plasma Processes in the Solar System:
Active Sun & Solar Cycle & Solar Wind
Interaction of the Solar Wind with Solar System Bodies
Physics of the Magnetosphere:
Boundary Layers, Current Systems, Reconnection, Storm Activity
Ionosphere & Aurora
Magnetospheres, Atmospheres & Aurora of other Planets
**Expected Learning Outcomes:**
Upon completion of this course, students should have a working understanding of space plasma physics, and the phenomenon that define the interaction of the solar wind with the near-space environment of the Earth and its magnetic field. Students should:

- Be able to define and derive the fundamental governing equations and characteristics of space plasmas.
- Be able to derive the motion of individual charged particles in static electric and magnetic field configurations.
- Understand how to generalize from the description of individual particle motions to that of a full particle population.
- Understand how to combine charged particle motion and equations governing electric and magnetic fields to create a self-consistent description of plasma dynamics.
- Demonstrate understanding of both physical equations and qualitatively descriptions of the Earth’s magnetosphere, and its dynamic response to the variable solar wind.
- Have a conceptual understanding of relevant research in the field, and be able to communicate it to broad public audience.

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**Course Requirements and Grading:**

1. There will be 6 graded homework assignments to support the lectures. While students are both allowed and encouraged to work together on the homework assignments, you will be responsible for individually understanding the material and everyone must turn in their own original work. Homework sets will be due as indicated in the assignment and on Canvas. Late assignments will be deducted 20% if turned in by the following week, but will not be given credit if turned in later (unless prior approval for a late assignment is requested).

   *You must turn in your assignments digitally through Canvas.*
   *Typing of assignments is strongly encouraged.*
   *If you prefer to hand draw sketches/drawings for assignments please take pictures and create a single, well ordered pdf of the assignment. (There are several online tutorials that can help you learn this useful skill!)*

2. There will be two midterms, one covering the first half of the course material, and the other on the latter half of the course material. **Both will be take-home and self-paced.**

   *Again, you must turn in your exams digitally through Canvas.*

3. Lastly, there will be an assignment culminating in a Poster Presentation on a space physics related topic of your choice. Topics can range from describing the state-of-the-science of specific investigation/phenomena, say the aurora of Jupiter, or a relevant NASA mission like the Van Allen Probes or Parker Solar Probe, or plasma propulsion as an enabling technology. More details and examples will be provided later in the term. There will be a summary and annotated bibliography due in Week 7.
**Assessment and Rationale:**

- Homework problem sets: 45%
- Midterm & ‘Final’ (equally weighted): 35%
- Summary & Annotated Bibliography: 10%
- Poster & Presentation 10%

The rationale behind the assignment breakdown is multi-tiered. Obviously, a large portion of the assessment is related to problem sets and self-paced exams. These provide a sense of how well you are learning the required course content, and if the overall course pacing is working. The assignments have specific purpose – some questions are designed to build intuition, while others push you to apply what you’ve learned in a new way. The exams are meant to assess the overall content acquisition. The last 20% of the course is related to how well you’ve truly understood the material, as synthesizing and translating published research for a public presentation is perhaps the best way to explore deeper conceptual understanding beyond the exercises of problem solving and memorization.

**CANVAS:**

Canvas will be used to store and disperse all materials for class. All lectures, notes and reading will be posted to Canvas, and it important that students insure they can access and receive notifications via canvas. The canvas student guide is at: [https://guides.instructure.com/m/4212](https://guides.instructure.com/m/4212)

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**Course Schedule:**

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<tr>
<th>Week</th>
<th>Topic and Deadlines</th>
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<tr>
<td>1</td>
<td><strong>Introduction</strong>: Basic context and historical overview for underlying concepts in Space Physics (Week 1 Reading – Chapter 1 – 2.3 in <em>Basic Space Plasma Physics</em>)</td>
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| 2 | **Fundamental Properties of Plasmas**: Plasma Criteria, Debye Length, Plasma Frequency, Quasi-neutrality  
**Single Particle Motion in Electric and Magnetic Fields**: Lorentz Force Law, Gyromotion, Bounce motion (Week 2 Reading – Chapter 3 in *BSPP*)  
*HW #1 Due Friday*
| 3 | **Single Particle Motion in Electric and Magnetic Fields II**: Adiabatic invariants, Drift motion, Generating currents, Quick review: Maxwell’s equations, Div, Grad, and Curl  
**Magnetohydrodynamics I**: Deriving fluid dynamics equations for charged particles and fields (moving from single particle motion description to averaging over many) (Week 3 & 4 Reading – Chapter 7 in *BSPP*)  
*HW #2 Due Friday*
| 4 | **Magnetohydrodynamics II**: Conservation equations, Generalized Ohm’s law, Collisions and resistivity, single fluid description  
**Magnetohydrodynamics III**: Plasma Beta, Alfvén Speed, Magneto-Sonic Speed, Mach numbers, Hydrostatic equilibrium, Dipole magnetic field  
*Short HW #2 Due Friday* |
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<th>Week</th>
<th>Topic</th>
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| 5    | **Magnetic Reconnection:** ‘Frozen in’ condition, Magnetic Diffusivity, Magnetic Reynold’s Number  
**Sun and Solar Wind:** Solar structure, Energy transport, Solar spectrum, Solar cycle and activity, Solar wind  
*HW #3 Due Friday (Includes a short summary of your initial idea for the poster)* |
| 6    | **Earth’s Magnetic Field:** Geodynamo, Magnetic field reversals, Dipole representation  
**Magnetosphere:** Boundary layers, Magnetospheric structure, Current Systems: Chapman-Ferraro, Ring, Cross Tail, Birkeland (Week 5 & 6 Reading – Chapter 5 in BSPP)  
**Magnetospheric Convection:** Application to the Earth’s magnetosphere, Dungey cycle, relationship to the aurora, Auroral structures, Observations: *in situ* and remote  
*Midterm #1 Due Wednesday* |
| 7*   | **The Dynamic Magnetosphere I:** Convection, Plasmasphere, Energy input, Substorms  
**The Dynamic Magnetosphere II:** Substorms Cont., Geomagnetic storms, Radiation Belt formation and variation, Man-made activity (Week 7 and 8 Reading – Chapter 4 in BSPP)  
*HW #4 Due Wednesday / Poster Summary and Bibliography Due Friday* |
| 8    | **Ionospheres:** Hydrostatic equilibrium atmosphere, Ionization processes, Solar and impact ionization profiles, Chapman layer  
**Ionospheres:** Chemistry, Transport, Aurora, Currents in the ionosphere  
*HW #5 Due Friday* |
| 9    | **Non-isotropic Conductivity:** Full derivation of the conductivity tensor including: Hall, Pederson, and Parallel conductivities, Description of resulting current systems  
**Comparative Planetology I:** Earth’s magnetosphere as a template, Magnetospheres of the outer planets (Jupiter, Saturn, Neptune, Uranus), Icy satellite interactions (Io, Europa, Ganymede), Aurora  
*Short HW #6 Due Friday* |
| 10   | **Comparative Planetology II:** Titan, Terrestrial planets: Mercury, Venus, Mars  
*In Class Poster Session*  
**Student Poster Slam** |
|      | **Final (Midterm #2) Due Weds of Finals Week** |

**Course Grading Rubric:**

A+ (>97%): Work of unusual distinction, only used when a student’s performance significantly exceeds all requirements and expectations for the assignment. This grade is rarely awarded.

A (90 – 97%): Excellent grasp of the material, with precise and insightful analysis and arguments. Must be well executed and reasonably free of errors. Can signify strong performance across the
board, or exceptional performance in one aspect of the assignment offsetting somewhat less strong performance in another.

**B (80-90%)**: Work that satisfies the main criteria of the assignment, and demonstrates good command of the material, but does not achieve the level of excellence that characterizes work of A quality.

**C (70-80%)**: Work that demonstrates a basic grasp of the material and satisfies at least some of the assigned criteria reasonably well.

**D (60-70%)**: Work that demonstrates a poor grasp of the material and/or is executed with little regard for college standards, but which exhibits some engagement with the material.

**F (<60%)**: Work that is weak in every aspect, demonstrating a basic misunderstanding of the material and/or disregard for the assigned question or prompt.

**Plus (+)** is added to a grade when the student’s performance is at the upper end of the range for that grade.

**Minus (-)** is added to a grade when the student’s performance is at the lower end of the range for that grade.

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**Course and University Policies:**

**General Etiquette**: I expect that students will exercise professional etiquette and participate as fully and as on time as possible. Derogatory or uncivil behavior will not be tolerated.

**Inclusion & Diversity**: The University of Oregon is working to create inclusive learning environments. I likewise facilitate a safe and open community for all students, regardless of race, ethnicity, creed, socioeconomic status, gender identity, or sexual orientation. All students are expected to contribute to a respectful, welcoming, and inclusive environment for every other member of the class. Note, class rosters are provided to instructors with students’ legal names. Please let me know if the name or pronouns I have for you are not accurate. It is important to me to address you properly.

**Accessible Education**: The University of Oregon and I are dedicated to fostering inclusive learning environments for all students and welcomes students with disabilities into all of the University's educational programs. The Accessible Education Center (AEC) assists students with disabilities in reducing campus-wide and classroom-related barriers. If you have or think you have a disability and experience academic barriers, please contact the AEC to discuss appropriate accommodations or support. Visit 360 Oregon Hall or aec.uoregon.edu for more information. You can contact AEC at 541-346-1155 or via email at uoaec@uoregon.edu.

**Attendance Policy**: This is a face-to-face course. Attendance is important because we will develop our knowledge through in-class activities that require your active engagement. We’ll have discussions, lecture, break-out groups activities and do other work during class that will be richer for your presence, and that you won’t be able to benefit from if you are not there. Excessive absences make it impossible to learn well and succeed in the course.
If you must miss class, it is your responsibility to keep up with the readings and get any notes for the day that aren’t posted on canvas from a classmate, and then see me or the TA during office hours if you have questions regarding the material you missed.

We know our UO community will still be navigating COVID-19, and some students will need to isolate and rest if they get COVID. Please take absences only when necessary, so when they are necessary, your prior attendance will have positioned you for success.

**Accommodation for Religious Observances:**
The University of Oregon respects the right of all students to observe their religious holidays, and will make reasonable accommodations, upon request, for these observances. If you need to be absent from a class period this term because of a religious obligation or observance, please fill out the [Student Religious Accommodation Request fillable PDF form](#) and send it to me within the first weeks of the course so we can make arrangements in advance.

**Academic Conduct Policy:**
Students are expected to abide by university policies on academic honesty, avoiding plagiarism, fabrication, cheating, and academic misconduct. Students must follow the UO Student Conduct Code: [http://dos.uoregon.edu/conduct](http://dos.uoregon.edu/conduct) which provides definitions of these terms and explanations of the university policy on the subject. Original work is assumed unless appropriately cited. Additional information about a common form of academic misconduct, plagiarism, is available at the Libraries’ [Citation and Plagiarism page](#).

**Generative AI Use:**
In general, I do not allow GenAI use or content to be turned in for assignments. You might find it helpful for brainstorming and organizing your project, but students may not use GenAI tools to produce submitted assignments in whole or in part. All work you submit for this course toward completion of course requirements must be your own original work. If you are in doubt or have questions about a particular GenAI tool and if its use is okay, check in with me and let’s discuss!

**Mandatory Reporter Status:**
I am a designated reporter. For information about my reporting obligations as an employee, please see [Employee Reporting Obligations](#) on the Office of Investigations and Civil Rights Compliance (OICRC) website. Students experiencing sex or gender-based discrimination, harassment or violence should call the 24-7 hotline 541-346-SAFE [7244] or visit [safe.uoregon.edu](http://safe.uoregon.edu) for help. Students experiencing all forms of prohibited discrimination or harassment may contact the Dean of Students Office at 5411-346-3216 or the non-confidential Title IX Coordinator/OICRC at 541-346-3123. Additional resources are available at UO’s [How to Get Support webpage](#).

I am also a mandatory reporter of child abuse. Please find more information at [Mandatory Reporting of Child Abuse and Neglect](#).

**Academic Disruption Due to Campus Emergency:**
In the event of a campus emergency that disrupts academic activities, course requirements, deadlines, and grading percentages are subject to change. Information about changes in this course
will be communicated as soon as possible by email, and on Canvas. If we are not able to meet face-to-face, students should immediately log onto Canvas and read any announcements and/or access alternative assignments. Students are also expected to continue coursework as outlined in this syllabus or other instructions on Canvas.

In the event that the instructor of this course has to quarantine, this course may be taught online during that time.

**Inclement Weather:**
It is generally expected that class will meet unless the University is officially closed for inclement weather. If it becomes necessary to cancel class while the University remains open, this will be announced on Canvas and by email. Updates on inclement weather and closure are also communicated as described on the [Inclement Weather webpage](https://example.com/inclement-weather).