ECE 598
Electrodynamics of continuum media

Raluca Ilie
Time: Tth 12:30 -13:50, Place: 3020 ECEB
Office Hours: Th 16:00-16:50, Place: TBD
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Course Description

This course is intended to engage graduate students interested in electrodynamics, remote sensing, and space sciences in advanced topics and new areas of research. Successful graduate students in this research area require a breadth of knowledge in advanced electromagnetics, the theory of electromagnetic fields in matter, and the interaction of fields and waves in a plasma environment. This course will specifically give students exposure to the fundamental electrodynamics and plasma processes that are operative in laboratory plasmas, plasma devices, and the space environment surrounding the Earth.

Prerequisites

ECE 452 or equivalent.

Main References

1. *Fundamentals of Plasma Physics*, J.A. Bittencourt, Springer
2. *Fundamentals of Plasma Physics* P. M Bellan, Cambridge.
3. *Advanced Engineering Electromagnetics*, C.A. Balanis, Wiley.

Topics Covered

Lectures	Topic of Instruction	Details
1-3	Particle Orbit Theory	charged particle motion in constant and uniform electromagnetic fields; charged particle motion in nonuniform electromagnetic fields; charged particle motion in time varying electromagnetic fields; adiabatic invariants
4-5	Elements of Kinetic Theory	phase space; distribution function; moments of the distribution function; the Boltzmann Equation; the Vlasov Equation; relaxation model for the collision term
6-8	Macroscopic Variables	review of tensors and Einstein notation; flux and particle current density; momentum and pressure tensors; higher moments of the distribution function; equilibrium state
9-12	Macroscopic Transport Equations	derivation of continuity, momentum and energy equations; treatment of collision terms; macroscopic equations for a conducting fluid
13-14	Plasma Conductivity and Diffusion	Langevin equation; DC and AC conductivity; free electron diffusion and ambipolar diffusion; diffusion in a fully ionized plasma
15	Basic Plasma Phenomena	electron plasma oscillations; Debye Shielding
16-18	Magnetohydrodynamics (MHD) Equations	magnetic viscosity; diffusion of magnetic field lines; frozen-in condition for magnetic fields in plasmas; magnetic pressure; plasma confinement in a magnetic field
19-22	MHD Waves	review of EM waves in free space; Alfven and magnetosonic waves; MHD equations for compressible non-viscous fluids; wave propagation in arbitrary directions; effect of displacement current; wave damping
23-25	Waves in Cold, Warm and Hot Plasmas	wave propagation in isotropic electron plasmas; wave propagation in magnetized cold plasma; wave propagation in parallel, perpendicular, and arbitrary direction relative to the background B field; two stream instability
26-28	Computational MHD	basic properties; generalizations of the MHD description; spatial discretization; finding weak solutions; TVD type schemes; keeping $\nabla \cdot \mathbf{B} = 0$; temporal discretization; principles of code design

Grading Policy

Homeworks (50%), 2 midterm exams (take home) ($2 \times 15\%$), final project (20%). The course will culminate in a term project on a topic of the student's choice, and each student will give a 10-minute presentation to the class on that topic in lieu of a final exam.

Homeworks

Homework will be assigned every Thursday (released via Classmail) and will be due the following Thursday at noon. Students are responsible for uploading their homework to Gradescope before the deadline. Late homework will be penalized by a reduction in total grade by 10%

Class Philosophy

- Research has demonstrated that the best learning occurs when the learner is actively involved. Thus, students are expected to come to class prepared to **think, participate in active learning activities, and learn.**

Class Policy

- The classroom is a learning environment. Please avoid distractions for yourself and others.
- Please turn off your cell phone during class. Do not keep your cell phone on your desk. NO TEXTING during class.

Academic Integrity

The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Students with Disabilities

To ensure equity for each student's educational experience, those with documented disability and required accommodations should contact me early in the semester so that all learning needs may be appropriately met. If you have not yet contacted DRES, please do so as soon as possible.

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu, or go to https://www.disability.illinois.edu. If you are concerned that you have a disability-related condition that is impacting your academic progress, there are

academic screening appointments available that can help diagnose a previously undiagnosed disability. You may access these by visiting the DRES website and selecting “Request an Academic Screening” at the bottom of the page.

Anti-Racism and Inclusivity Statement

This classroom is a place where you will be treated with respect. I welcome individuals of all ages, backgrounds, beliefs, ethnicities, genders, gender identities, national origins, religious affiliations, sexual orientations, abilities, and other visible or non-visible differences. All members of this class are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

The intent is to raise student and instructor awareness of the ongoing threat of bias and racism and of the need to take personal responsibility in creating an inclusive learning environment. The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity, and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Sexual Misconduct Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University’s Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options. A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/confidential. Other information about resources and reporting is available here: wecare.illinois.edu.

Religious Observances

Illinois law requires the University to reasonably accommodate its students’ religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of

your religious observances. If a conflict exists, you should notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.