ECE507: Plasma Physics and Applications

Course Description: This is a first course in plasma physics designed to provide the student with the fundamental principles underlying most of the modern scientific and industrial applications of plasmas. A first section on fundamental concepts includes the discussion of elements of plasma physics relevant to terrestrial plasmas. Two subsequent sections, devoted to the study of low- and high-density plasmas, both expand on other theoretical concepts and introduce concrete examples of plasma production and application.

Course objective: The course provides an introduction to the fundamental physical concepts, theory, and applications of plasmas with the objective of providing a basic understanding of the low density plasmas used from processing by the semiconductor industry, the glow discharges used by the lighting industry and the much higher density plasmas used for the efficient generation of extreme ultraviolet and x-ray radiation.

Instructors: Prof. Jorge Rocca, Dr. Fernando Tomasel

Classes on Tuesday, Thursday 8:00 to 9:15 AM Engineering B105

Course Evaluations: Two mid-term exams (30% each) and a final project (40%).

Homework will be given but not graded. Solutions to homework problems will be provided.
Midterms will cover the material discussed in class during the first and second half of the course.
The subject for the final project will be proposed by the students and reviewed and approved by the instructors. The project is expected to be carried out independently by the students, with occasional guidance from the instructors. The deliverables for the final project will be a written report and an oral presentation. Guidelines for the final project will be provided by the instructors during the second half of the course

Text: notes provided by the instructors.

Additional Class Details for 2022

Associated Term: Spring Semester 2022
CRN: 17562
Campus: Main
Schedule Type: Lecture
Instructional Method: Face-to-Face
Credit Hours: 3
Prerequisite: ECE 342.
Last Day to Add without Override: Jan 23, 2022
Last Day to Add with Override: Feb 02, 2022
*** Overrides must be obtained from the instructor or department associated with this class.
Last Day to Drop: Feb 02, 2022
May Withdraw from Course: Feb 03, 2022 through Mar 21, 2022

Fundamental Concepts

Concept of Plasma
Macroscopic quantities and the concept of temperature
Thermal distribution of velocities in a plasma
Quasineutrality
Debye length/plasma parameter
Plasma frequency
Maxwell equations and single particle motion
Maxwell's equations
Single particle motion
Motion in uniform, constant fields
Motion in non-uniform, constant fields
Motion in time-varying fields
Plasmas as Fluids
Continuity equation
Momentum equation
Conservation of Energy
Equation of state
Particle collisions and radiation
Elastic and inelastic collisions
Electron impact ionization and recombination
Photoionization and radiative recombination
Electron impact excitation and de-excitation
Radiative decay
Equilibrium properties
Boltzmann's relation
Saha equilibrium
Coronal equilibrium
Nonmagnetized plasma dynamics
Plasma oscillations
Dielectric constant and conductivity
Ohmic heating
Electromagnetic waves
Electrostatic waves
Low density plasmas
DC glow discharges
Qualitative characteristics of glow discharges
V-I characteristics of DC glow discharges
Breakdown phenomena
Transition to glow
Cathode and anode layers
Physics of DC sheaths
Hollow cathode discharges
Positive column

Diffusion of charged particles: electrical and thermal conductivity
Steady-state regimes of non-equilibrium discharges
Calculation of steady state values for electron temperature, electric field and electron density
Glow discharge instabilities
Application examples
RF-produced plasmas
Capacitively-coupled discharges
General characteristics
Equivalent circuits
Sheath dynamics
Charged particle motion
Low pressure discharges
Moderate pressure discharges
Application examples
Inductively coupled discharges
General characteristics
Equivalent circuits
Power absorption
Low pressure discharges
Moderate pressure discharges
Application examples
Diagnostics for low density plasmas
Langmuir probes
Others
High density plasmas
Introduction
Radiative properties of dense plasmas
Deviation from thermodynamic equilibrium
Collisional radiative model
Dense plasma focus and Z-pinches
Non-neutral plasma – The magnetically confined electron gas
The dynamic pinch: shock waves in magnetic fields
Elementary theory: the snowplow model
Stability
Plasma equilibrium and stability
Hydromagnetic equilibrium
Instabilities in low temperature plasmas: thermal instabilities in monoatomic and molecular gases, electron attachment and others.
Instabilities in hot plasmas: Rayleigh – Taylor instability, flute or sausage instability, kink or tearing instability and others.
Laser-produced plasmas
Laser-target interaction
Plasma expansion
Radiative properties
Diagnostics for dense plasmas
Spectroscopy
Interferometry
Application of dense plasmas:

Extreme ultraviolet lithography
X-ray Lasers
Inertial Confinement Fusion
Important information for students:

Masks are required inside university buildings. You must also meet university vaccine or exemption requirements.

All students are expected and required to report to the COVID Reporter (https://covid.colostate.edu/reporter/) when:

- You suspect you have symptoms of COVID, regardless of whether or not you are vaccinated and even if your symptoms are mild
- You have tested positive for COVID through a non-CSU testing site, such as home test or test at a pharmacy
- You believe you may have been exposed to COVID go to the COVID Reporter and follow the guidance under "I believe I have been in close contact with someone who has COVID-19." This guidance will depend upon your individual circumstances
- You will not be penalized in any way for reporting symptoms or concerns.
- Do not ask me as your instructor to report for you. It is your responsibility to report through the COVID Reporter promptly.

As your instructor I may not ask you about vaccination status or if you have COVID but you may freely volunteer to send me information from a public health official if you have been asked to isolate or quarantine.

When you complete the COVID Reporter, the CSU Public Health office is notified. Once notified, that office will contact you and, depending upon each situation, will conduct contact tracing, initiate any necessary public health requirements and notify you if you need to take any steps.

If you do not have internet access to fill out the online COVID-19 Reporter, please call (970) 491-4600.

For the latest information about the University's COVID resources and information, including FAQs about the spring semester, please visit the CSU COVID-19 site https://covid.colostate.edu/.