Course Overview
This course provides an introduction to Physics of Plasmas, and its application to Space Physics, at the beginning graduate/doctoral student level. No prior knowledge of Plasmas will be assumed, but Mathematical tools and basic physical concepts learned as an Undergraduate will be assumed. This course is recommended for students with research interests in Space Physics. Emphasis will be on physical insights, application, and problem solving rather than formal derivations.

Course Outcomes

CO1: To be able to define a Plasma, explain concepts of Plasma Oscillations and Debye Shielding.
CO2: To be able to describe motion of charged particles in various prescribed (coupled/otherwise) electric and/or magnetic field configurations (including a dipole magnetic field), and the adiabatic invariants.
CO3: Be familiar with various approaches to Plasma Physics and under what conditions these can be used.
CO4: Understand Fluid description of Plasma, what kind of waves are supported, Physics of such waves, and be able to derive the Dispersion relations.
CO5: Understand the Physics of Instabilities and be familiar with their characteristics.
CO6: Be able to apply Plasma Physics theories to real-world plasma systems – e.g. Solar Wind – Magnetosphere interactions

Course Syllabus

Unit – 1

Unit – 2
Single particle motion in prescribed E&B fields : $\mathbf{E} \times \mathbf{B}$ drifts, Grad-$\mathbf{B}$ drift, Curvature drift, Magnetic moment, Adiabatic invariants of the particle motion, Magnetic mirror, Motion in a dipole magnetic field
Unit – 3
Two fluid description of Plasmas: Two - Fluid Plasma equations, Electron Plasma Waves or Langmuir Waves in $B_0 = 0$ Plasmas, Electrostatic ion waves or Ion Acoustic waves (in $B_0 = 0$ Plasmas), High frequency electromagnetic (EM) waves in $B_0 = 0$ Plasmas, Upper hybrid waves in magnetized plasmas, Electrostatic ion waves in a magnetized plasma, Instabilities -- Two-Stream Instability

Unit – 4

Unit – 5
Vlasov description of Collisionless plasmas: Vlasov equation, Equilibrium or steady-state solutions – Examples, Electrostatic waves & Landau Damping, Current sheet structures

Text Books

Reference Books

Evaluation Pattern
Internal (70%) : Problem sets (Once every week)
External (30%): Final Exam (Closed book)