PHY-451 Introduction to Plasma Physics

Credit Hours: 3-0

Pre-requisite: None

Course Objectives: This course is intended to introduce the basic concepts of plasma physics. We will examine both the single-particle and the fluid behaviour of plasma, waves in plasmas, and equilibrium and stability of plasma.

Course Contents: Definition of Plasma, plasma parameters, single particle motion, fluid description of Plasma, wave propagation in Plasma, diffusion and mobility, diffusion across a magnetic field, classification of instabilities.

Detailed Course Contents: occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding, plasma parameters criteria for plasma, application of plasma physics, single particle motion in uniform electric E and magnetic B fields, single particle motion in nonuniform B field, single particle motion in non-uniform E field, time varying E and B fields, adiabatic invariants, fluid description of plasma, fluid equations, fluid drifts perpendicular to B, fluid drifts parallel to B, the plasma approximation, wave propagation in plasma, plasma oscillations, electron waves, ion waves, electrostatic electron oscillations perpendicular to B, electrostatic ion waves perpendicular to B, electromagnetic waves with B0=0, electromagnetic waves perpendicular to B0, cutoffs and resonances, electromagnetic waves parallel to B0, whistler mode, Faraday rotation, hydromagnetic waves, magnetosonic waves, diffusion and mobility, collision parameters, diffusion parameters, decay of plasma by diffusion, steady state solutions, diffusion across a magnetic field, hydromagnetic equilibrium, concept of β, diffusion of magnetic field into a plasma, classification of instabilities, the two-stream instability, the gravitational instability, resistive drift waves, the Weibel instability.

Course Outcomes: Students will be able to understand:

- the broad range of physical phenomena which determine the behavior of plasmas and the importance of collective effects
- learn problem solving skills for plasma physics
- understand the role of plasma in a range of naturally occurring phenomena and laboratory applications

Textbook: F. F. Chen, Introduction to Plasma Physics and Controlled Fusion, Plenum Press, 1984.

Reference Books:

T. J. M. Boyd and J. J. Sanderson, The Physics of Plasmas by, Cambridge University Press, 2003.

Weekly Breakdown		
Week	Ch. Sect.	Topics
1	Chen 1.1-1.7 Chen 2.1-2.2	Occurrence of Plasma in Nature, Definition of Plasma, Concept of temperature, Debye Shielding, Plasma parameters criteria for Plasma, Application of Plasma Physics Single particle motion in uniform Electric E and magnetic B fields
2	Chen 2.3-2.8	Single particle motion in Nonuniform B field, Single particle motion in Nonuniform E field, Time varying E and B fields, Adiabatic Invariants
3	Chen 3.1-3.3	Fluid description of Plasma, Fluid equations
4	Chen 3.4-3.6	Fluid drifts perpendicular to B, Fluid drifts parallel to B, The Plasma Approximation
5	Chen 4.1-4.4	Wave propagation in Plasma, Plasma Oscillations, Electron Waves
6	Chen 4.5-4.11	Ion Waves, Electrostatic electron oscillations perpendicular to B, Electrostatic ion waves perpendicular to B
7	Chen 4.12-4.14	Electromagnetic waves with B_0=0, Electromagnetic waves perpendicular to B0, Cutoffs and Resonances
8	Chen 4.16	Electromagnetic waves parallel to B_0
		Midterm Exam
9	Chen 4.17	Whistler mode, Faraday rotation
10	Chen 4.18-4.19	Hydromagnetic Waves, Magnetosonic waves
11	Chen 5.1	Diffusion and mobility, Collision parameters, Diffusion parameters
12	Chen 5.2	Decay of Plasma by diffusion
13	Chen 5.3, 5.5	Steady state solutions, Diffusion across a magnetic field
14	Chen 6.2-6.4	Hydromagnetic Equilibrium, Concept of β, Diffusion of magnetic field into a plasma
15	Chen 6.5-6.9	Classification of instabilities, The two-stream instability, The Gravitational instability, Resistive drift waves, The

		Weibel instability