PHY-921 Plasma Physics

Credit Hours: 3+0

Prerequisite: None

Course Objectives: The physics of plasmas is important to understand a wide range of phenomena, such as evolution of stars & galaxies, interaction of the solar wind with earth's magnetic field, industrial processes such as computer chip fabrication, generation of intense sources of electromagnetic radiation and energetic particles. Therefore, this course will provide students the basic knowledge to understand these phenomena.

Core Contents: Occurrence of plasma in nature, definition of plasma, concept of temperature, Debye shielding, plasma parameters, criteria for plasma, occurrence of plasma in nature, fluid equations, wave propagation in plasma, ion waves, hydromagnetic waves, kinetic theory of plasma, Vlasov equation

Detailed Course Contents: The detailed course contents are given with week wise breakdown below.

Course Outcomes: Students will

- Understand broad range physical phenomena which are determined by the behavior of plasmas & its collective effects
- Learn problem solving skills for plasma physics
- Understand the role of plasma in laboratory applications

Textbooks:

1. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion, Plenum Press, New York, 1984 (referred as Chen)
2. D. C. Montgomery and D. A. Tidman, Plasma Kinetic Theory, McGraw Hill Book Company, New York, 1964 (referred as M&T)

Reference Books:

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

2. N. A. Krall and A. W. Trivelpiece, Principles of Plasma Physics, McGraw-Hill Book Company, 1973.

Weekly Breakdown		
Week	***Section***	***Topics***
1.	Chen 1.1-1.7, 2.1-2.2	Occurrence of Plasma in Nature, Definition of Plasma, Concept of temperature, Debye Shielding, Plasma parameters, Citeria 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 4.1-4.5	Wave propagation in Plasma, Plasma Oscillations, Electron Waves
6.	Chen 4.6-4.11	Ion Waves, Electrostatic electron oscillations perpendicular to B, Electrostatic ion waves perpendicular to B
7.	Chen 4.12-4.15	Electromagnetic waves with B_0=0, Electromagnetic waves perpendicular to B_0
8.	Chen 4.16-4.17	Electromagnetic waves parallel to $B_{0,}$ Whistler mode, Faraday rotation
9.	Chen 4.18-4.20	Hydromagnetic Waves, Magnetosonic waves
10.	Chen 6.1-6.4	Hydromagnetic Equilibrium, Concept of *β,* Diffusion of magnetic field into a plasma
11.	Chen 6.5-6.9	Classification of instabilities, The two-stream instability, The Gravitational instability, Resistive drift waves, The Weibel instability

12.	Chen 7.1-7.3	Kinetic theory of Plasmas, Definition of distribution function, Kinetic averages of physical quantities, Equations of kinetic theory, Derivation of fluid equations,
13.	Chen 7.4-7.5	Comparison of kinetic theory and fluid model, Plasma oscillations and Landau damping
14.	M&T 10.1-10.2	The Vlasov Equation, Linearization of Vlasov Equation
15.	M&T 10.3	Derivation of the general conductivity tensor from Maxwell-Vlasov set of equations