23SC812 PLASMA PHYSICS 4 0 0 4

Course objective:

The main objective of this course is to enhance the concepts in plasma physics with focus on techniques of plasma production and measurements, waves and instabilities, single particle motion in electric and magnetic fields, plasma confinement, diffusion and resistivity, plasma diagnostics, and applications.

Course Outcomes

In the end of the course students should be able

CO1: Understand the basic properties and criteria for plasma

CO2: Analyze the electrodynamics and fluid equations for plasma

CO3: Introspect the particle motions under the influence of external electric and magnetic field

CO4: Examine the diffusion and transport properties of plasma

CO5: Understand the diagnostic method to study the plasma properties

UNIT I:

INTRODUCTION: Fundamentals of Plasma Plasma state – characterization: Occurrence of Plasma in nature – Definition of Plasma – concept of temperature – Debye Shielding – The Plasma parameters – Criteria for Plasma – Applications.

SINGLE-PARTICLE MOTIONS: Uniforms E and B fields – Non uniform B fields – Non – uniform E field – Time-Varying E field– Time-Varying B field– Adiabatic Invariants.

PLASMA AS A FLUID: Relation of Plasma Physics to Ordinary Electromagnetics – field equation of motion – Fluid drifts perpendicular to B - fluid drifts parallel to B – Plasma approximation

UNIT II:

WAVES IN PLASMAS: Representation of waves - Group velocity - Plasma oscillations - Electron plasma waves – Sound waves - Ion waves - Validity of the plasma approximation - Electrostatic electron oscillations perpendicular to B - Electrostatic Ion waves perpendicular to B - Lower hybrid frequency - Electromagnetic waves with $B_0 = 0$ - Electromagnetic waves perpendicular to B_0 - Cutoffs and Resonances - Electromagnetic waves parallel to B_0 - Experimental consequences - Hydro magnetic waves - Magneto sonic waves - CMA diagram.

UNIT III:

DIFFUSION AND RESISTIVITY: Diffusion and mobility in weakly Ionized gases - Decay of a plasma by diffusion - steady state solutions – Recombination - Diffusion across a magnetic field - Collisions in fully ionized plasmas - Single-fluid MHD equations - Diffusion in fully ionized plasmas - Solutions of the diffusion equation - Bohm diffusion and Neoclassical diffusion.

EQUILIBRIUM AND STABILITY: Hydromagnetic Equilibrium - concept of β - Diffusion of magnetic field into a plasma - Classification of instabilities - Two-stream instability - Gravitational instability - Resistive drift waves - Weibel instability.

UNIT IV:

KINETIC THEORY: Meaning of f (v) - Equations of kinetic theory – Derivations of the fluid equation – plasma oscillations and Landau damping – meaning of Landau Damping –Physical

derivation of Landau Damping – BGK and van Kampen modes – Experimental verification – Kinetic effects in a Magnetic field.

UNIT V:

PLASMA DIAGNOSTICS: Electrical methods: Langmuir probe - spectroscopic methods – Line spectrum of a plasma – low density plasma – high density plasma ionization state of a plasma – particle methods: Beam of charged particle to measure electric field in a plasma – measurement of the density of natural particles and charged particles.

NUCLEAR FUSION: Introduction, Lawson criteria, Fundamentals of inertial confinement fusion, Fundamentals of magnetic confinement method, Tokamak, Hydrodynamics of implosion.

TEXT BOOKS/ REFERENCES:

1. Chen F F "Introduction to Plasma Physics and Controlled Fusion", Plenum Press, New York, 1980.
2. Plasma physics- plasma state of matter – S.N.Sen, Pragati Prakashan, meerut
3. Krall N.A. and Trivelpiece A.W. "Principle of Plasma Physics", Tata McGraw- Hill Publishing Company, New Delhi, 1972.
4. Dendy R "Plasma Physics", Cambridge University Press, New York, 1996.
5. Friedberg J P "Ideal Magnetohydrodynamics"
6. Seshadri S R "Fundamental of Plasma Physics",
7. Chanchal Uberoi "Introduction to Unmagnetized Plasma", Prentice Hall of India Pvt. Ltd., New Delhi, 1997.