Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NPHD511	Plasma Physics: Fundamentals and Applications	3	0	0	3

Prerequisite

- Students must have detailed knowledge of Optics and Electrodynamics. Students should have completed courses on Mathematical Physics and Statistical Mechanics

Course Objective

- To introduce the fundamental knowledge of plasma state of matter, and discuss about its various properties, and applications.
- To prepare them for advanced studies and research in the modern laboratory-plasma and space-plasma.

Learning Outcomes

Upon successful completion of this course, students will learn about:

- The fundamental behavior of electrons and ions under electric and magnetic fields, fluid model of plasma – properties of electrostatic and electromagnetic waves, equilibrium and instabilities in plasma, a more refined treatment of plasma – the kinetic theory, applications in space physics, laser-plasma science and technology for fusion and particle acceleration.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Definition of plasma, Debye shielding, plasma parameters, applications of plasma physics, Motion of charged particles in magnetic and electric fields; adiabatic invariants, transit time magnetic pumping, plasma heating. Fluid equation of motion, plasma approximation.	9	This unit provides a broad overview about the plasma state of matter and relevant applications. Besides, it also delivers the quantitative understanding of charged particle motion under electric and magnetic fields and adiabatic invariants in a plasma along with the fluid theory of plasma.
2	**Waves in plasmas:** 'Plasma oscillations, electrostatic electron and ion waves, electromagnetic waves in plasma' with and without external magnetic fields, ordinary and extraordinary waves with dispersion relations, Faraday rotation.	8	This unit provides the quantitative nature of various electrostatic and EM waves in plasmas.
3	**Diffusion and resistivity:** Parameters; collisions and discrete particle effects, Coulomb collisions, transport processes, conductivity, diffusion along and across magnetic field; magnetohydrodynamic (MHD) plasma models.	6	This unit provides the properties of electron fluid, ion fluid and ambipolar diffusion in plasma, the origin of plasma resistivity and its dependence's on physical parameters.
4	**Equilibrium and stability:** Linear waves, fluctuations in a stable plasma and instabilities in magnetized plasma; two-stream instability.	3	This unit provides the idea of plasma instabilities
5	**Kinetic theory:** Velocity distribution, equations of kinetic theory, electron plasma waves and Landau damping; solutions of Vlasov-Maxwell equation; cyclotron damping.	6	This unit provides the kinetic description of plasma, and various wave-particle interaction phenomena.
6	**Plasmas in space:** Structure of sun, solar activity, solar flares, coronal heating, solar wind and its interactions with magnetized planets, magnetic reconnection.	5	This unit provides the knowledge of solar physics, solar wind and magnetic reconnection
7	**Plasmas in laboratory:** Plasma confinement schemes, Tokomak, inertial confinement fusion (ICF), laser-plasma interactions and brief introduction of laser-plasma accelerators.	5	This unit provides the examples of modern plasma applications in laboratory
	Total	**42**	

Textbooks:

1. Introduction to Plasma Physics and Controlled Fusion, Vol I; Chen; Springer; 2006.
2. Elements of Space Physics, R. P. Singhal, PHI Learning, 2009.

Reference Books:

1. The Physics of Laser Plasma Interactions; W. L. Kruer; Westview Press (2003).
2. Introduction of Plasma Physics; Goldston and Rutherford; Taylor and Francis; 1995.
3. Basic Space Plasma Physics; Baumjohann and Treumann; World Scientific; 1996.
4. Fundamentals of Plasma Physics; Bittencourt; Springer; 2004.