Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NMED534	**Fundamentals of Electro Magneto-Hydrodynamic Flows**	3	0	0	3

Course Objective

- Students should be able to learn basic concepts of the Electro Magneto-Hydrodynamic Flows (EMHD Flows).
- Students will learn about the some of the actual physical problems with a realistic appreciation of the assumptions and the approximation involved while dealing such flow problems.
- To provide the students a connection between classical electricity and magnetism, thermodynamics and fluid mechanics.
- To provide basic ideas electrodynamics of the moving media.

Prerequisites

The students should have fundamental knowledge about Fluid Mechanics, Thermodynamics and Heat Transfer.

Learning Outcomes

Upon successful completion of this course, students will:

- Understand the basics of basic concepts of the Electro Magneto-Hydrodynamic Flows (EMHD Flows);
- Learn some of the actual physical problems involving EMHD and the assumptions and the approximation involved;
- Understand the connection between classical electricity and magnetism, thermodynamics and fluid mechanics;
- Understand the basic ideas electrodynamics of the moving media;
- Learn about the basics of stability of EMHD flows.

Module	Topics to be Covered	Lecture Hours	Learning Outcome
1	**The Electrodynamics of Moving Media and Electromagnetic body force:** Classical Maxwell's equations, The Maxwell-Lorentz transformation, The Lorentz force on a charged particle, The constitutive equations and the boundary conditions, Induced electromagnetic force, Scalar and vector potential, The Poynting vector, The stress tensor formulation of the body force, force density in magnetofluid mechanics	8	Understanding of the basics of Electrodynamics of Moving Media, The basics of Maxwell's equations and the induced electromagnetic force and the associated constitutive equations and boundary conditions.
2	**The Fluid Equations with EMHD:** The fundamental equations of viscous flows, Thermodynamics of magnetohydrodynamics, The second law and the irreversible thermodynamics, Flows under the action of electromagnetic body force, The associated boundary conditions,	8	Understanding of the basics of the fluid equations in conjunction with EMHD body force, The associated thermodynamics of EMHD flows and the boundary conditions.

	Terminal voltage and equivalent circuits		
3	**The magneto-hydrodynamics approximations:** The MHD approximation, Fluid equations under MHD approximation, Magnetic transport and Alfvén waves, Bernoulli's equation in MHD, Kelvin's circulation theorem in MHD, The static MHD pinch	6	Understanding of the basics of MHD approximations, the corresponding Bernoulli's equation and Kelvin's circulation theorem, and Alfvén waves as a consequence of MHD flows.
4	**Incompressible viscous MHD flows**: MHD Poiseuille, Couette flows, Channel flows with insulated, ideally conducting and conducting wall perpendicular to applied magnetic field, Flows between co-axial rotating cylinders with radial magnetic field, Applications in the field of tribology: MHD lubricating flows between parallel rotating discs, MHD inclined slider bearing with transverse and tangential magnetic field.	6	Understanding of the incompressible viscous MHD flows with some canonical problems and practical applications.
5	**Unsteady incompressible viscous MHD flows**: An electrodynamic plate problem, Time-varying MHD flows: Channel and Poiseuille flows, The Rayleigh problem in MHD.	4	Understanding of the unsteady incompressible viscous MHD flows with some canonical problems.
6	**Waves in MHD and Compressible MHD flows**: Plane waves in fluids including displacement currents, Transverse waves in moving fluids, Normal and oblique MHD shocks, 1D MHD compressible MHD flows, Flows in channels of varying area, The vortex generator, MHD flows with large and small conductivity, Basics of MHD boundary layer and hypersonic flows.	10	Understanding of the plane waves and compressible MHD flows.

Text Books:

1. The Electromagnetodynamics of Fluids, W. F. Hughes and F. J. Young, John Wiley & Sons Inc., New York, 1966

Reference Books:

1. Fundamental fluid mechanics and magnetohydrodynamics, Roger J. Hosking, and Robert L. Dewar, Springer, New York, 2016.
2. Introduction to magnetohydrodynamics, Peter Alan. Davidson, Vol. 55. Cambridge university press, 2016.

Engineering magnetohydrodynamics, George W. Sutton, and Arthur Sherman, Dover Publications, 2006.