

Magnetohydrodynamics

Academic Year: (2024 / 2025)

Review date: 24-05-2021

Department assigned to the subject: Physics Department

Coordinating teacher: GARCIA GONZALO, LUIS

Type: Electives ECTS Credits : 3.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Basic knowledge of electromagnetic theory (graduate level) and plasma physics.

OBJECTIVES

The student will acquire during this course the knowledge of Magnetohydrodynamics phenomena. At the end of the course, the student will be able to understand the formalism of Magnetohydrodynamics and to solve equilibrium and stability problems.

DESCRIPTION OF CONTENTS: PROGRAMME

I. IDEAL MAGNETOHYDRODYNAMICS

1. The MHD model. Introduction. Description of the ideal MHD model. Deduction of the ideal MHD model. Region of validity.
2. General properties of ideal MHD. Boundary conditions. Local conservation laws. Global conservation laws. Magnetic flux conservation.
3. Equilibrium. General considerations. Equilibrium equations. Virial theorem. Magnetic surfaces and magnetic coordinates. Resolution of equilibrium equations.

II. IDEAL MHD STABILITY

4. Basic concepts. Exponential stability. General linearized stability equations. Normal modes. Waves in a homogenous plasma. Properties of the force operator. The energy principle. Classification of MHD instabilities.
5. Localized instabilities. Suydam ζ_s criterion. Toroidal curvature effects. Interchange modes. Mercier criterion. Ballooning modes in 2-D (tokamak) and 3-D (stellarator) configurations.
6. Global modes. Internal kink modes in a cylinder and a tokamak. External kink mode. Pressure plasma limits due to ideal stability.

III. RESISTIVE MHD STABILITY

7. Effect of resistivity on stability. Change of magnetic topology. Tearing modes. Linear theory. Quasi-linear saturation. Mode coupling and nonlinear saturation. Magnetic reconnection.
8. Resistive interchange and ballooning modes. Linear theory. Nonlinear saturation and its effect on confinement.

IV. MAGNETIC DIAGNOSTICS

LEARNING ACTIVITIES AND METHODOLOGY

Lectures where the theoretical concepts are explained

- The lecturer will provide a file with the following information (1 week in advance)
- Lecture notes of main topics to be discussed during the session
- Chapters/sections in each of the text books provided in the bibliography where the student can read about these topics

ASSESSMENT SYSTEM

% end-of-term-examination:	100
% of continuous assessment (assignments, laboratory, practicals...):	0

Written work of a research topic.

An oral presentation of the work is made at the end of the semester.

% end-of-term-examination:	100
% of continuous assessment (assignments, laboratory, practicals...):	0

BASIC BIBLIOGRAPHY

- J.P. Freidberg Ideal Magnetohydrodynamics, Plenum Press, 1987
- P.M. Bellan Fundamentals of Plasma Physics, Cambridge University Press, 2008