Course memo, Spring 2026 for ED2210 *Electromagnetic Waves in Dispersive Media*

This course on provides the theoretical frameworks for understanding, analysing and for future studies is electromagnetic waves in dispersive and anisotropic medias. Examples of such medias as plasmas, crystals and many other dielectrics.

As a student you will learn new concepts, learn to derive dielectric properties of specific medias. You will solve wave equations and analyse the energy, and momentum carried by the electric and magnetic fields, as well as the media itself. Towards the end of the course, you'll also learn about emission processes from free charged particles, which has many applications from medicine to plasma physics.

Grading scale

A, B, C, D, E, FX, F

Education cycle

Second cycle

Main field of study

Electrical Engineering

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

After passing the course, the student shall be able to

- use Maxwell's equations to formulate and explain electromagnetic wave equations in homogeneous media
- identify and categorise the symmetries of dielectric response tensors and their dispersive, anisotropic and dissipative properties
- derive dielectric response tensors for simple electromechanical media
- derive, analyse and solve wave equations for electromechanical media
- for a given wave-solution, analyse the dispersion relation, calculate group and phase velocities and the energy of the wave

- calculate and analyse how waves propagate in birefringent media and magnetized plasma
- describe how electromagnetic waves can be emitted from free charged particles and describe technical applications for these emission processes.

Course contents

The course is divided into four modules:

- **Basic properties of electromagnetic waves and Fourier analysis**: At the beginning of the course, we will study the bases that are needed later in the course, primarily basic electromagnetics, the concept of plane waves, Fourier transforms and Green functions.
- **Electromagnetic response of media**: Here, we will study how different media react to electromagnetic fields. We will develop a general theory of homogeneous media and compare with traditional models from electrostatics and magnetostatics. Applications are studied for anisotropic media and dispersive media with resonances. Furthermore, a theory of the dielectric response of plasma will be developed and studied.
- **Wave equations and the properties of waves**: A general theory of waves in homogeneous media will be presented. Here, the wave equation is represented algebraically as an eigenvalue problem. A number of important examples will be studied in detail, including phenomena such as birefringence (with applications to quarter wave plates), Faraday rotation, and so-called cutoff-resonance pairs. The basic theory of plasma waves is presented and a number of important waves are studied, including plasma oscillations, Langmuir waves, ion-acoustic waves, Alfvén waves and compressible waves.
- **Emission processes**: Here, we focus on emission from individual charged particles. A general theory of wave emission is presented and Larmor formulas are derived with applications to bremsstrahlung, Thomson scattering and cyclotron emission.

Didactics

The course will be given through 14 lectures, 6 home assignments and a written exam. The lectures will be given in the Greta Woxén room, except the lecture on the 9 February that is given in the room Ivar Herlitz, Teknikringen 33. The lectures will include a combination of new theory and exercises. As the theory part will include new concepts, it is highly recommended that the students try to read the material in advance. Since the class is relatively small, we will try to keep the lectures interactive, thus student should be prepared to participate in discussions and calculations.

The assignments are individual, but the students are allowed to discuss the assignments. However, in the end each student has to write and hand in their own solution.

Language

The course will be given in English. However, students are allowed to write the assignments and the exam in Swedish.

Detailed list of lectures

A detailed list of the lectures in the course are given in Canvas.

Specific prerequisites

Completed course in electromagnetic theory equivalent to EI1220/EI1320.

Active participation in a course where the final examination is not yet reported in LADOK is considered equivalent to completion of the course.

Registering for a course is counted as active participation. The term 'final examination' encompasses both the regular examination and the first re-examination.

Recommended prerequisites

Courses about mathematical methods in physics and functions of complex variables are recommended.

Course literature

- D.B. Melrose and R.C. McPhedran, “Electromagnetic processes in dispersive media”
  E-book downloadable using KTH account from:
  https://libris.kb.se/bib/12013175
- The lecture notes.

Examination

- TENA - Examination, 4,0 hp, betygsskala: A, B, C, D, E, FX, F
- ÖVNA - Exercises, 2,0 hp, betygsskala: P, F

Based on recommendation from KTH’s coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.