UNIVERSITY OF GOTHENBURG

DEPARTMENT OF PHYSICS

FYM335 Physics and applications of electromagnetic fields and optical materials, 7.5 credits

Elektromagnetiska fält och optiska material: fysik och tillämpningar, 7,5 högskolepoäng

Second Cycle

Confirmation

This course syllabus was confirmed by Department of Physics on 2019-11-04 to be valid from 2019-11-04, spring semester of 2020.

Field of education: Science 100%
Department: Department of Physics

Position in the educational system

The course is elective within the master program in physics.

The course can be part of the following programmes: 1) Complex Adaptive Systems, Master's Programme (N2CAS) and 2) Physics, Master's Programme (N2PHY)

Main field of studies	*Specialization*
Physics	A1N, Second cycle, has only first-cycle course/s as entry requirements

Entry requirements

Bachelors degree in physics or equivalent.

Applicants must prove their knowledge of English: English 6/English B from Swedish Upper Secondary School or the equivalent level of an internationally recognized test, for example TOEFL, IELTS.

Learning outcomes

The course aims to provide the students with a firm understanding of the physics and applications of electromagnetic fields and optical materials. Electromagnetic waves are arguably one of the most important concept of physics in modern society—enabling

fundamental scientific breakthroughs like the detection of elementary particles as well as being the foundation of numerous industrial, medical, and consumer applications.

The students will first learn how charged particles move in electromagnetic fields, with applications in thermonuclear fusion and mass spectroscopy. The course will then proceed with a study of the optical radiation emitted by moving charged particles and when charged particles interact with materials. This will lead to an understanding of phenomena such as synchrotron radiation, Cherenkov radiation, and bremsstrahlung, and their importance for, e.g., materials science and astrophysics.

The second part of the course aims to deepen the students' knowledge of optical waves interacting with various materials, highlighting their importance for applications in photonics and laser technology. In this way, the course will enable the students to understand state-of-the-art devices and prepare the students to participate in next-generation electromagnetic and photonic technology.

On successful completion of the course the student will be able to:

- Understand the importance of electromagnetic fields and waves in physical science and technology;
- Describe and understand the behaviour of charged particles in electromagnetic fields, the radiation emitted by charged particles, and the interaction of charged particles with materials;
- Describe and understand the propagation of electromagnetic waves in various optical media, such as dielectrics, metals, semiconductors, anisotropic crystals, nonlinear optical media, etc.;
- Make quantitative predictions of the above physical phenomena;
- Relate the macroscopic properties of optical media to their internal microscopic properties;
- Know and understand applications of electromagnetic fields and optical materials in different application areas including optics, materials characterization, astrophysics, and elementary particle detection;
- Apply basic theoretical models to real optical devices and experiments;
- Be acquainted with contemporary research fields related to electromagnetic fields and optical materials.

Course content

PART 1: Introduction
- Microscopic Maxwell's equations and electromagnetic waves, including polarization; coherence; diffraction; and optical force

PART 2: Charged particles interacting with electromagnetic fields and materials
- Particles in uniform and nonuniform electric and magnetic fields

- Radiation by moving charged particles, including synchrotron radiation and Cherenkov radiation
- Collisions of charged particles with materials; energy loss
- Bremstrahlung

PART 3: Optical waves in macroscopic materials
- Macroscopic Maxwell's equations
- Optical waves in dielectrics and metals; dispersion; absorption; surface waves and polaritons
- Scattering on small particles, including cross sections; optical theorem; Mie scattering; basics of multipole analysis
- Microscopic models of dielectric functions
- Optical waves in anisotropic crystals
- Electro-optics and nonlinear optics

Form of teaching

The course consist of lectures, problem-solving sessions, guest lectures about contemporary physics research, and a project involving for example a computer calculation related to contemporary physics research or technology. Attendance at the guest lectures and conference is compulsory.

Language of instruction: English

Assessment

Students will be examined by way of (1) compulsory assignments to be handed in during the course; (2) a compulsory oral exam at the end of the course; (3) the students' performance on the project and their presentation at the compulsory conference. To receive any passing grade (U,G,VG), at least that grade must be earned both on the assignments and on the oral exam, as well as a passing grade on the project.

If a student, who has failed the same examined element on two occasions, wishes to change examiner before the next examination session, such a request is to be submitted to the department in writing and granted unless there are special reasons to the contrary (Chapter 6, Section 22 of Higher Education Ordinance).

In the event that a course has ceased or undergone major changes, students are to be guaranteed at least three examination sessions (including the ordinary examination session) over a period of at least one year, though at most two years after the course has

ceased/been changed. The same applies to work experience and VFU, although this is restricted to just one additional examination session.

Grades

The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).

Course evaluation

The results of and possible changes to the course will be shared with students who participated in the evaluation and students who are starting the course.