IM2660 Solid State Physics 7.5 credits

Fasta tillståndets fysik

This is a translation of the Swedish, legally binding, course syllabus.

If the course is discontinued, students may request to be examined during the following two academic years

Establishment

Course syllabus for IM2660 valid from Autumn 2009

Grading scale

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

Education cycle

Second cycle

Main field of study

Physics

Language of instruction

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

Intended learning outcomes

This course gives an introduction to solid state physics with emphasis on properties of electro-technically important crystalline materials. The primary theme is to study the basic theory of structure, composition and physical properties of crystalline materials. At the end of the course, you should be able to

- describe different types of crystal structures in terms of the crystal lattice and the basis of constituent atoms
- formulate the theory of X-ray diffraction in the reciprocal lattice (k-space) formalism and apply this knowledge to generalize the formulation for matter waves
- describe the different physical mechanisms involved in crystal binding identifying the repulsive and attractive interactions and correlate these with the atomic properties
- formulate the theory of lattice vibrations (phonons) and use that to determine thermal properties of solids
- formulate the problem of electrons in a periodic potential, examine its consequence on the band-structure of the solid and develop a framework that explains the physical properties of solids in terms of its band-structure
- apply the knowledge obtained to make a judicious choice of a solid in terms of its desired property
- identify the materials encountered in the course in a representative modern device/component, analyze why these are used and propose better alternatives if necessary
- follow the thread in progressive improvements made to model the physical properties of solids and at each stage explain why they are necessary, what added knowledge is obtained and what draw-backs still remain
- recognize that the developed k-space formalism to describe phonons, electrons, is more general and can be used to describe waves in a periodic media and identify such 'out-of-the-course' physical situations/problems.

Course contents

Condensed matter consists of a very large number of interacting entities and their physical properties, and these can be atoms, ions, electrons, spin etc. Studying this is essential to understand the properties of solids and thereby the design of electronic materials. The specific topics that will be covered are crystal structure, reciprocal lattice, crystal binding, lattice dynamics, theory of free electrons, distributions, energy bands, semiconductors, Fermi-surfaces, magnetism and superconductivity. At the beginning of the course, a brief overview covering some relevant concepts and formalisms in quantum mechanics and atomic physics will be given. This is intended only for recapitulating the basic concepts and to get familiar with notations/terms that will be used in the remainder of the course. Concerning the main topics of the course (listed above), we will follow the prescribed course book, Introduction to solid state physics by Charles Kittel, and hand-outs given at the tutorials and on selected lecture topics. All the listed topics will be covered in detail except Magnetism and Superconductivity which will be at a more introductory level. These will be dealt extensively in other follow-up courses. During the course, we will also be emphasizing how a variety of physical phenomena can be understood by analyzing the problem in the so-called k-space (also referred to as wave-vector space, reciprocal lattice). You will be introduced to this powerful formalism and its application to understand diffraction of waves (e.g. X-rays, neutrons, electrons) by crystals, the properties of phonons (ref. lattice vibrations) and finally the behavior of electrons in a periodic potential. In addition, special lectures will be given on current research topics such as semiconductor low-dimensional structures and photonic crystals. These lectures are intended to highlight the importance/relevance of the course and also to appreciate how certain formalisms/concepts that one comes across in the study of crystalline solids can be applied in very different contexts, e.g. behavior of light in periodic dielectric media, of course noting the fundamental differences and similarities.

Specific prerequisites

Courses of the technology science block or equivalent; familiarilty with basic quantum mechanics. For master-program students, basic requirements as specified for admission.

Course literature

Introduction to Soild State Physics, Charles KittelUpplaga: Förlag: John Wiley and Sons Inc. År: 2005ISBN: 0-471-68057-5

Examination

- LAB1 - Laboratory Work, 1.5 credits, grading scale: P, F
- TEN1 - Examination, 6.0 credits, grading scale: A, B, C, D, E, FX, 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.

Grading Scale:
A/B/C/D/E/Fx/F

Other requirements for final grade

WRITTEN EXAM
Examination Scheme:Passing the exam gives you 6 ECTS. The written exam will be evaluated on a maximum number of 24 units. These are split: Part 1- descriptive and derivations (12 units) and Part 2 - Problems/ calculations (12 units).
Of these, you have to get a minimum of 4 units in each category.
Part I: Course book, lecture notes or your own notes, lap-top/pocket computers: NOT ALLOWED
Part II: Kittel's book, calculator, mathematical handbook: ALLOWED
Minimum points required to pass the exam: 12 units

CONTROL EXAMS: During the course, there will be two control exams, each of 45 min duration. The scores obtained in these exams are treated as "bonus" points for the final exam.

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.