# Solid State Physics SK2771

## COURSE CONTENT

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, an overview of materials and components, and physical phenomena placing the course in context of modern technological developments is given. 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 lecture and tutorial materials. All the listed topics are covered in detail except magnetism and superconductivity, which are discussed extensively in other follow-up courses. During the course, we will also be emphasizing the description of a variety of important physical properties and phenomena in solids 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.

## LEARNING OBJECTIVES

This course gives an introduction to solid state physics with emphasis on properties of technologically 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, the students 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 in a representative modern device/component, analyze why these materials are used
- 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 MATERIAL

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

Lecture and tutorial materials, posted on the course page in Canvas.

## PERFORMANCE EVALUATION

The primary evaluation is via a final written exam and two quizzes. The quizzes, each of 45 min duration, are given during the course and the scores obtained are treated as "bonus" points for the final exam.

Examination Scheme:

The written exam is evaluated on a maximum number of 24 units and consists of two parts: Part 1- conceptual and descriptive questions (12 units). Course book, lecture notes or your own notes, lap-top/pocket computers: NOT ALLOWED

Part 2 – Problems/calculations, derivations (12 units). Course book, calculator, handbooks-Physics, Mathematics: ALLOWED

## GRADING CRITERIA

| GRADE | Only final exam (Max 24) | 2 quizzes + final exam (MAX 28) |
|---|---|---|
| A | >22-24 | >24-28 |
| B | >19-22 | >20-24 |
| C | >16-19 | >16-20 |
| D | >13-16 | >13-16 |
| E | 12-13 | 12-13 |
| FX | >10 < 12 | >10 < 12 |