SK2758
Solid state physics, 7.5 credits, VT 2019

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.

Teaching
32 h lectures, 16 h tutorials and 4 h laboratory work

Literature
• Charles Kittel, Introduction to solid state physics, 8th edition, John Wiley & Sons Inc., 2005, ISBN 978-0-471-41526-8 (available at Kårbokhandeln).
• All other course material can be downloaded from Canvas

The literature is a standard course book within the field, but some students may find it too compact to read. Alternative course books are:

S.H. Simon, The Oxford solid state basics, Oxford University Press, ISBN 978-0-19-968077-1 (comparable, easier to read, superconductivity is missing)
J.R. Hook & H.E. Hall, Solid state physics, Wiley, ISBN 0-471-92805-4 (comparable, introduces reciprocal space at a very late stage in the book)
N. Ashcroft & D. Mermin, Solid state physics, Saunders, ISBN 0-03-083993-9 (broader, easy to read, not updated since 1974)
M.L. Cohen and S.G. Louie, Fundamentals of condensed matter physics, Cambridge University Press, ISBN 9787-0-521-51331-9 (reasonably comparable with Kittel, somewhat more theoretical, semiconductors is missing)

Requirements
To pass the course, students must have a pass grade on both TEN1 and LAB1. The grade on the full course is the same as the grade on TEN1.

TEN1 - Written exam (6.0 credits)
The final examination in the course is a 5 h written exam with a theory part and a problem part. Bonus points (max 4) on the exam can be obtained by passing 4 digital exams during the course. 24 points can be obtained on the exam, which gives a maximum of 24 + 4 = 28 points in total. The grading is based on the total number of points and is as follows:

Grade A: > 22 points
Grade B: 19 - 21.5 points
Grade C: 16 – 18.5 points
Grade D: 13 – 15.5 points
Grade E: 12 - 12.5 points
Grade Fx: 11 - 11,5 points
Grade F: < 11 points

Allowed aid during the exam:
Theory part: Ruler, pocket calculator, mathematics handbook BETA
Problem part: Ruler, pocket calculator, mathematics handbook BETA, one course book (e.g. C. Kittel, Introduction to solid state physics), CGS-to-SI conversion sheet

Students with grade FX can do additional work in the course to obtain grade E. Such work has to be finished latest 4 weeks after the result on the exam has been made official. Detailed information about the required additional work (construction and solution of a novel problem) can be found in Canvas.

LAB1 - Laboratory work (1.5 credits)
To pass the examination, students must participate in the laboratory work and hand in two written laboratory reports (one on X-ray diffraction and one on band structure calculations) with a pass grade on each of them.

Syllabus
Classification of materials, atomic binding, crystal structure, direct and reciprocal lattice, X-ray diffraction on crystals, lattice vibrations, phonons, Debye and Einstein models, free electron model, hear capacity, electric transport in metals, band structure, semiconductors, superconductivity, magnetism.

Teachers

Examiner & lectures:	Magnus Andersson, magnusan@kth.se
Tutorials:	Magnus Andersson, magnusan@kth.se
X-ray diffraction lab:	Margareta Linnarsson, marga@kth.se
Band structure lab:	TBA

Administrative information

Registration for the exam is mandatory and follow KTH general rules. The learning management system Canvas is used throughout the course and all detailed information related to the course can be found there. Registration for laboratory sessions are made in Canvas. Students with registrations on previous course offerings or course codes should make sure that they get access to this year's course offering in Canvas. Contact kursexp@physics.kth.se to resolve any issues related to this.

Lectures

Chapter numbering refer to 8th edition of C. Kittel, Introduction to solid state physics. More detailed information including page numbers can be found in Canvas.

Lecture	Chapter	Content
1	1	Introduction, crystal structure
2	1, 2, 6	Crystal structure, reciprocal lattice
3	2	Reciprocal lattice, X-ray diffraction
4	2	X-ray diffraction
5	3	Crystal binding
6	4	Phonons
7	5	Phonons
8	6	Free electrons, heat capacity
9	6, 7	Electron transport, heat capacity
10	7	Band structure
11	8	Semiconductors
12	8, 9	Semiconductors, metals
13	10	Superconductivity
14	11	Diamagnetism, paramagnetism
15	12	Ferromagnetism, antiferromagnetism
16	1-12	Reserve, repetition

Tutorials

The following subjects will be covered during the tutorials

Tutorial	Subject
1	Crystal structure
2	Reciprocal lattice, X-ray diffraction
3	X-ray diffraction, crystal binding
4	Phonons
5	Free electrons an electric transport
6	Semiconductors
7	Metals, superconductors
8	Magnetism

Laboratory work

The X-ray laboratory work takes place in our course laboratory in the Electrum building in Kista (Isafjordsgatan 22, elevator B, third floor). Registration for this occasion is mandatory and is done through Canvas.

The band structure laboratory is a home laboratory work that you make using your own computer. Registration of students working together on this laboratory must be made in Canvas, so that all group members get the proper credit for their work.

Reading instructions

A detailed description of the parts of the course book that is included in this course can be found in Canvas.