Lund University

Faculty of Science

FYSC23, Physics: Solid State Physics, 7.5 credits

Fysik: Fasta tillståndets fysik, 7,5 högskolepoäng

First Cycle / Grundnivå

Details of approval

The syllabus was approved by The Board of Faculty of Science on 2021-03-15 and was last revised on 2024-11-06 by The Education Board of Faculty of Science. The revised syllabus comes into effect 2024-11-06 and is valid from the autumn semester 2025.

General information

The course is a compulsory course at first cycle level for a Degree of Bachelor in physics.

Language of instruction: English

Main field of study	*Specialisation*
Physics	G2F, First cycle, has at least 60 credits in first-cycle course/s as entry requirements

Learning outcomes

The course intends to broaden the knowledge of quantum mechanics from the previous course FYSB22 to extended systems with a very large number of atoms. This new understanding is applied on solids, surfaces and nanostructures to learn the basic aspects for these systems. Another important aspect is to give examples of modern electronic and nanometer size components and their influence on the society. Understanding of spectroscopic methods, how they are used in experimental studies and how they are connected to the activities at MAX IV and ESS are central in the course. The course also gives the opportunity to practise problem-solving by means of analytical and numerical aids, and to write scientific reports.

The course is based on the knowledge described in the course syllabi for the courses: FYSA12, FYSA13, FYSA14, MATA21, MATA22, NUMA01, MATB22, FYSB21, FYSB22, FYSB23, FYSB24 and good knowledge of their content facilitates for the student to carry out the course.

Intended learning outcomes in the programme syllabus refer to the programme syllabus of Degree of Bachelor in physics at Lund University which corresponds to qualitative aim for general qualification in the Higher Education Ordinance in turn.

1, 2, 3, 7, 8 is interim target against intended learning outcomes 1 in the programme syllabus

5 is interim target against intended learning outcomes 2 in the programme syllabus.

4, 5, 6 is interim target against intended learning outcomes 3 in the programme syllabus.

5, 6 is interim target against intended learning outcomes 4 in the programme syllabus.

5, 6 is interim target against intended learning outcomes 5 in the programme syllabus.

7, 8, 9 is interim target against intended learning outcomes 6 in the programme syllabus.

7, 8, 9 is interim target against intended learning outcomes 7 in the programme syllabus.

10 is interim target against intended learning outcomes 8 in the programme syllabus.

Knowledge and understanding

On completion of the course, the students shall be able to:

1. Explain basic concepts and identify central fields in solid state physics such as crystal structure, reciprocally lattice, lattice vibrations, band structure and the free electron model, conductors, semiconductors, insulators, and magnetism.

2. Describe the physical main principles behind some of today's electric and opto-electronical components (for example transistors, light emitting diodes, solar cells)

3. Give example of and explain ongoing research in solid state physics qualitatively including experimental research at MAX IV and ESS and how machine learning can be used in theoretical solid state physics.

Competence and skills

On completion of the course, the students shall be able to:

4. Solve simple numerical problems related to the physical models that are presented during the course.

5. Use software to simulate and visualise simple physical models.

6. Plan, carry out, analyse and present experiments in main fields of study in solid state physics.

Judgement and approach

On completion of the course, the students shall be able to:

7. Assess the applicability of the physical models and limitations in relation to real systems in solid state physics.

8. Reflect on, discuss and problematise an application of modern solid state physics and its potential effects in a certain social sector.

9. Give example of how different electric components in the solid state physics can contribute to improvement of energy efficiency and important challenges in our society.

10. Summarise and reflect on own progress for knowledge and skills based on intended course learning outcomes.

Course content

The course treats:

- crystal structure
- diffraction and reciprocally lattice
- crystal binding
- phonons: lattice vibrations and thermal properties
- free electron gas
- electronic band structure
- semiconductors
- Fermi surfaces and metals
- superconductivity
- Quantum Hall effect
- magnetism
- surface structures and, for simple systems, exemplary numerical calculations of the density of the states
- nanostructures and, for simple systems, exemplary numerical calculation of electron transport on the nanometer scale

Course design

The teaching consists of teaching sessions, group tuition and supervision in connection with laboratory sessions, computer exercises and projects. All components related to the laboratory work, the computer exercises and the project is compulsory. At the end of the course, a study visit is carried out at MAX IV and ESS, where current research is presented by local researchers.

Assessment

Examination takes place in writing in the form of an examination and through laboratory projects and written reports during the course, and through a written self-reflection at the end of the course.

Compulsory examination corresponds 5 credits and assess mainly intended learning outcomes 1, 3, 7, 8, 9.
Laboratory projects and reports correspond to 2 credits and mainly assess intended learning outcomes 1, 4, 5, 6, 7.
Numerical projects and reports correspond to 0.5 credits and mainly assess intended learning outcomes 4, 5, 6, 7.
The self-reflection is compulsory and mainly assesses intended learning outcomes 10.

Students who do not pass an assessment will be offered another opportunity for assessment soon thereafter.

The examiner, in consultation with Disability Support Services, may deviate from the regular form of examination in order to provide a permanently disabled student with a form of examination equivalent to that of a student without a disability.

Grades

Grading scale includes the grades: Fail, Pass, Pass with distinction
To pass the whole course requires approved examination passed laboratory sessions self-reflection and participation in all compulsory components:

- Introduction meeting,
- Laboratory and numerical projects,
- Self-reflection over learning.

Calculation of grade

- Written examination gives a percentage result that corresponds to the part achieved points, relatively the total possible number of points and the grades Fail, Pass or Pass with distinction. The limit for Pass is normally 50% and for Pass with distinction 80%.
- For laboratory and numerical projects (where implementation and reports are taken into account) a percentage result is given which is relative to the total number possible credits. The result for the project part is decided by an arithmetic mean of these percentage result. The grades are Fail, Pass or Pass with distinction. The limit for Pass is 50%, and for Pass with distinction, 80% is.
- Final result and grade for the whole course are calculated as a weighted mean of percentage result for written examination and laboratory and numerical projects, where examination is counted two thirds and projects be counted a third. The limit for Pass is 50% and for Pass with distinction 80%.

Entry requirements

Entry to the course requires general entry requirements and 60 credits including physics knowledge equivalent to:

- FYSA12 Physics: Introduction to university physics with mechanics and electromagnetism, 15 credits,
- FYSA13 Physics: Introduction to university physics with optics, waves and quantum physics, 7.5 credits,
- FYSA14 Physics: Introduction to university physics with thermodynamics, climate and experimental methodology, 7.5 credits,
- FYSB21 Physics: Mathematical methods for oscillations, waves and diffusion, 7.5 credits,
- FYSB22 Physics: Basic quantum mechanics, 7.5 credits,
- FYSB23 Physics: Basic statistical Physics and quantum statistics, 7.5 credits, and
- FYSB24 physics: Atomic and Molecular Physics, 7.5 credits,

and 45 credits in Mathematics including knowledge equivalent to:

- MATA21 mathematics: One variable calculus, 15 credits,
- MATA22 Mathematics: Linear algebra 1, 7.5 credits,
- NUMA01 Numerical analysis: Computational programming with Python, 7.5 credits,

- MATB21 Mathematics: Multivariable analysis 1, 7.5 credits, and
- MATB22 Mathematics: Linear algebra 2, 7.5 credits.

Students who have obtained the equivalent knowledge by other means may also be admitted to the course.

Further information

The course is part of the Bachelor's programme in physics, theoretical physics, or astrophysics. The teaching is based on the assumption that the student follows the program and has assimilated the knowledge in the previous courses, and takes other program courses in parallel. For those who have acquired equivalent knowledge in other ways, the course can be taken as a stand-alone course.

The course may not be included in qualification together with FYSC13 Physics: Solid State Physics, 7.5 credits or the equivalent earlier courses.

The course is given by the Department of Physics, Lund University.