Reg No: FAK2 2008/9:32

Faculty of Technology and Science
Physics

Syllabus

Course Approval
The syllabus was approved by the Faculty Board of Technology and Science on 26 November 2008, and is valid from the Spring semester of at Karlstad University.

Course Code: CBAD80
Nanoscience II, 7.5 ECTS Credits
(Nanovetenskap II, 7.5 Swedish credit points)
Degree Level: Master
Progression Level: D

Language of Instruction
The language of instruction is English but the course can also be taught in Swedish if all students speak Swedish.

Prerequisites
To be accepted to the course, approval on the following courses (or the equivalent) is required: Nanoscience I, Quantum Physics I and II, and Solid State Physics.

Major Field of Study
Physics

Aims

Upon completion of the course, students should be able to:
- give an account of basic physical concepts of low-dimensional physics and physical systems on the nanometer scale, including nanothreads and quantum dots
- describe the realization of two-dimensional electron gases in MOSFET-transistors and in semiconductor heterostructures, as well as in components on a nanoscale, based on two-dimensional electron gases
- critically decide on which length- and time scales that semiclassic theory and quantization effects are relevant to different physical phenomena and processes
- account for, quantitatively and in depth, for charge transport on the nanometer scale, including the following concepts: semiclassic and ballistic charge transport, the transport properties of a magnetic field, the quantized Hall effect, quantized conductance, the Landauer-Büttiker theory, coherent transport, single electron tunneling
- give a general description of the use of spin polarization in new types of electronic components
- use AFM and/or STM for imaging and basic manipulation of nanostructures.

Course Content

The course introduces the basic concepts and theories of low-dimensional physics with a focus on charge transport in structures on the nanometer scale. Starting from established theory in solid state physics and semiconductor physics, the course covers the effects that appear when the dimensions and length scales diminish, which makes the semiclassic theory of electron dynamics no longer relevant.

The course contains the following elements:
- Semiclassic theory of charge transport, Boltzmann equation.
- The band structure of semiconductors, the tight-binding method, metal-semiconductor and semiconductor-semiconductor interfaces, MOSFET and HEMT transistors.

- Electron dynamics in a magnetic field, the quantized Hall effect.
- Ballistic charge transport, nanowires, quantum point contacts, quantized conductance, Landauer-Büttiker formalism.
- Phase coherence, the Aharonov-Bohm effect, resonant tunneling.
- Single electron tunneling (SET), the Coulomb blockade, SET transistor, the electronic structure of quantum dots.
- Introduction to spintronics.

Reading List

See separate document.

Examination

Examination is the form of written or oral exam, take-home assignments, and a mandatory laboratory assignments.

Grades

One of the grades 5 (Distinction), 4 (Some Distinction), 3 Pass , or Fail (U), is awarded in the examination of the course if it is part of an engineering program. For other programs and for independent courses, one of the grades Fail (U), Pass (G), or Distinction (VG) is awarded in the examination of the course.

Quality Assurance

Follow-up relating to learning conditions and goal-fulfilment takes place both during and upon completion of the course in order to ensure continuous improvement. Course assessment is based on student views and experiences as reported in written course evaluations and/or group discussions. Students will be informed of the result of the evaluation and of the measures to be taken.

Course Certificate

A course certificate will be provided upon request.

Additional Information

Students who enrolled before 1 July 2007 will complete their studies in accordance with the requirements of the earlier admission. Upon completion students may request degree and course certificates to be issued under the current ordinance if they meet its requirements.

The local regulations for studies at the Bachelor's and Master's levels at Karlstad University, ref. C2007/368, stipulate the obligations and rights of students and staff.

The course is a mandatory part of the program in Engineering Physics and the Master program in Nanomaterials.

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