Reg No: CBAD80/20171

Faculty of Health, Science and Technology
Physics

Syllabus

Nanoscience II

Course Code:	CBAD80
Course Title:	Nanoscience II *Nanovetenskap II*
Credits:	7.5
Degree Level:	Master's level
Progressive Specialisation:	Second cycle, has second-cycle course/s as entry requirements (A1F)

Major Field of Study:
FYA (Physics)
TKA (Engineering Physics)

Course Approval
The syllabus was approved by the Faculty of Health, Science and Technology 2016-09-08, and is valid from the Spring semester 2017 at Karlstad University.

Prerequisites
To be accepted to the course, completed courses in physics, 50 ECTS credits and mathematics, 35 ECTS credits, are needed, as well as approval on the following courses (or the equivalent): Nanoscience I, Physical Electronics, Quantum Physics II, and Solid State Physics.

Learning Outcomes
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 nanowires and quantum dots
- describe the realization of two-dimensional electron gases in semiconductor heterostructures, as well as components on a nanoscale, based on two-dimensional electron gases
- critically decide on which length and time scales that semiclassic theory, and quantisation effects, respectively, 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 quantized Hall effect, quantized conductance, the Landauer-Büttiker theory, transport properties in a magnetic field, coherent transport, the Aharonov-Bohm effect, single electron tunnelling and single-electron transistor
- give a general description of the use of spin polarization in new types of electronic components

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, the Boltzmann equation.
The band structure of semiconductors and graphene, the tight-binding method.
Metal-semiconductor interfaces and two-dimensional electron gases in semiconductor heterostructures, nanostructures based upon two-dimensional electron gases
Ballistic charge transport, nanowires, quantum point contacts, quantized conductance, Landauer-Büttiker formalism.
Electron dynamics in a magnetic field, the quantized Hall effect.
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
Assessment is based upon a written and oral exam, presentations at seminars, and take-home assignments.

Grades
One of the grades U (Fail), 3 (Pass), 4 (Some Distinction), 5 (Distinction) 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 U (Fail), G (Pass), or VG (Distinction) 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 evaluation is partly based on student views and experiences obtained in accordance with current regulations and partly on other data and documentation. Students will be informed of the result of the evaluation and of any measures to be taken.

Course Certificate
A course certificate will be provided upon request.

Additional information
The local regulations for studies at the Bachelor's and Master's levels at Karlstad University 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 Degree Program in Engineering Physics