



Faculty of Health, Science and Technology
Physics

Syllabus

Nanoscience II

Course Code:	CBAD80
Course Title:	Nanoscience II <i>Nanovetenskap II</i>
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 2025-09-01, and is valid from the Spring semester 2026 at Karlstad University.

Prerequisites

Physics, 50 ECTS credits, including Nanoscience I, 7.5 ECTS credits, Mathematics, 35 ECTS credits, and registered for Quantum Physics II, 7.5 ECTS credits, and Physical Electronics, 7.5 ECTS credits, plus upper secondary level English 6 or English level 2, or equivalent

Learning Outcomes

Upon completion of the course, students should be able to:

1. give an account of basic physical concepts of low-dimensional physics and physical systems on the nanometer scale, including nanowires and quantum dots,
2. describe the realisation of two-dimensional electron gases in semiconductor heterostructures, as well as components on a nanoscale, based on two-dimensional electron gases,
3. critically decide on which length and time scales that semiclassical theory and quantisation

effects, respectively, are relevant to different physical phenomena and processes,

4. give a quantitative and in-depth account of charge transport on the nanometer scale, including the following concepts: semiclassical and ballistic charge transport, quantised conductance, the Landauer-Büttiker theory, transport properties in a magnetic field, the quantised Hall effect, coherent transport, the Aharonov-Bohm effect, single electron tunnelling, and single-electron transistor, and
5. give a general description of the use of spin polarisation 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 semiclassical theory of electron dynamics no longer relevant.

The course covers the following:

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, quantised conductance, Landauer-Büttiker formalism.

Electron dynamics in a magnetic field, the quantised 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 an individual written exam, presentations at seminars, and individual hand-in assignments.

If students have a decision from Karlstad University entitling them to Targeted Study Support due to a documented disability, the examiner has the right to give such students an adapted examination or to examine them in a different manner.

Grades

One of the grades U (Fail), 3 (Pass), 4 (Some Distinction), or 5 (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 and Master levels at Karlstad University stipulate the obligations and rights of students and staff.