Board of Teacher Education
Physics

# Syllabus

## Physics III and Physics Education

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| **Course Code:** | FYGL31 |
| **Course Title:** | Physics III and Physics Education<br>*Fysik III med didaktisk inriktning* |
| **Credits:** | 30 |
| **Degree Level:** | Undergraduate level |
| **Progressive Specialisation:** | First cycle, has at least 60 credits in first-cycle course/s as entry requirements (G2F) |

**Major Field of Study:**
FYA (Physics)

**Course Approval**
The syllabus was approved by the Board of Teacher Education 2018-02-12, and is valid from the Autumn semester 2018 at Karlstad University.

**Prerequisites**
Mathematics 1-90 ECTS cr with 75 ECTS credits completed, including Practical Placement 1 and Physics 1-60 ECTS cr with 37.5 ECTS credits completed

**Learning Outcomes**
The aim of the course is that students acquire the enhanced knowledge in the field required for teaching physics in secondary education.

Module 1 Thermodynamics and Statistical Physics, 7.5 ECTS cr.
The aim of the module is that students acquire the fundamentals of classic thermodynamics for closed systems in equilibrium, statistical physics, and statistical thermodynamics. The course also provides the background to significant technical applications and a basis for discussions of energy issues.

Upon completion of the module, students should be able to:
1. give an account of the phases of pure substances and describe phase transitions,
2. analyse processes of closed systems as regards the first and second laws of thermodynamics, especially in relation to pure substances and ideal gases,
3. apply and describe the consequences of the second law in realistic situations,
4. calculate thermodynamic properties based on different forms of free energy,
5. give an account of links between classic and statistical thermodynamics,
6. give an account of the microscopic significance of entropy,
7. calculate the microcanonical and canonical ensembles of simple multiparticle systems, and
8. calculate the state sum and free energy of a canonical ensemble,
9. give an account of the meaning of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, and use corresponding distribution functions.

Module 2 Introductory Modern Physics, 7.5 ECTS cr
The aim of the module is that students acquire basic knowledge of modern physics and an overview of its development in the 20th century which has affected our worldview as well as given rise to important technical innovations.

Upon completion of the module, students should be able to
1. describe the structure of the atom by using quantum physical concepts, such as quantization, probability density, energy states, and quantum numbers, and use the quantum model to obtain relevant physical parameters,
2. apply their knowledge of the behaviour of particles and waves in order to describe the wave-particle duality and estimate its consequences for physical phenomena,
3. analyse basic quantum mechanical model systems,
4. analyse the effect of relativistic velocity on physical phenomena,
5. apply the concepts stated above to basic physical problems, formulate the problems mathematically, calculate and critically assess the magnitude of the results,
6. give an account of the origins of the quantum theory and situate the discoveries of modern physics in the history of science.

Module 3, Practical Placement 2, 7.5 ECTS cr
Students develop their professional skills by applying research and experience based knowledge of learning and development in teaching.

Upon completion of the module, students should be able to:
1. act in accordance with the core values specified in the education act and curricula,
2. give an account of legislation concerning school obligations to prevent and take measures against bullying and abuse and analyse local school policy on discrimination,
3. integrate, under some supervision, a norm critical perspective in the pedagogical activities with a focus on equality and equity,
4. communicate professionally with students and staff, one-on-one and in groups, using a language in speech and writing that is functional and adequate to the situation,
5. under some supervision, plan, lead and conduct teaching sequences on the basis of national curricula and subject knowledge and subject-specific pedagogy,
6. plan and conduct teaching with consideration of students' different circumstances and under supervision reflect on special education needs,
7. analyse their own teaching and present arguments for showing how it is related to curricula and knowledge of subject and subject pedagogy,
8. under supervision assess students' knowledge progress and social situation at school and discuss how this can be communicated with students, guardians and staff,
9. with some guidance, use digital tools in pedagogical activities, and
10. discuss their own professional development and identify their need of further development.

Module 4 Experimental Physics in Education, 7.5 ECTS cr
The aim of the course is that students acquire basic knowledge and skills in planning and conducting science experiments in the field of modern physics, and develop skills in presenting problems and results, orally and in writing. The course also includes enhanced knowledge of modern physics and current physics education research.

Upon completion of the module, students should be able to:
1. demonstrate deepened knowledge of experimental methods in some parts of modern physics and their use in current research, development and applications,
2. independently design, plan and carry out a supervised experiment based on a given problem in one of the fields mentioned above,
3. perform literature searches on a given problem and assess the results yielded in relation to scientific literature,
4. compile the result of the experiment in a science report and present and discuss the result orally in a

scientific manner,
5. discuss experiments and the role of experiments from a teacher perspective.

**Content**
Module 1 Thermodynamics and Statistical Physics, 7.5 ECTS cr

Instruction is in the form of lectures, exercises and mandatory laboratory sessions.

Classical thermodynamics (4.5 ECTS cr)
Basic concepts: thermodynamic systems, state, equilibrium, process, cycle. Temperature and the zeroth law of
thermodynamics, internal energy, pressure, enthalpy, work, heat. The phases of pure substances and phase transitions, state diagrams and phase diagrams. Ideal and non-ideal gases. The first law of thermodynamics for closed systems. Changes in the internal energy and enthalpy of ideal gases, heat capacity. Heat reservoir, heat engine, heat pump, and cooling process, the second law of thermodynamics. Reversible and irreversible processes, the Carnot cycle, the thermodynamical temperature scale, reversible heat engines, heat pumps, and cooling processes. Entropy, the principle of increasing entropy, changes in entropy for ideal gases. Analysis of heat engines, ideal cycles. Thermodynamical potentials, Helmholtz and Gibbs free energies, Maxwell's relations. The link between macroscopic properties and statistical mechanics.

Statistical Physics (3 ECTS cr)
Kinetic theory for ideal gases. Probability distribution, mean, and deviation. Bernoulli processes and binomial distribution. Normal distribution, the law of large numbers, the central limit theorem, the connections between macroscopic properties and statistical mechanics. Macrostates and microstates, ensembles. Isolated systems and the microcanonical ensemble, the equiprobability principle, the entropy of isolated systems. Systems in thermal equilibrium with heat reservoirs and the canonical ensemble, the Boltzmann distribution, state sum, response functions and heat capacity, and entropy and the third law of thermodynamics. Free energy and statistical thermodynamics. Entangled particles, the Pauli principle, bosons and fermions. Classic and quantum mechanical ideal gas; the Maxwell-Boltzmann, Bose-Einstein, and Fermi- Dirac distributions; black body radiation.

Module 2 Introductory Modern Physics, 7.5 ECTS cr
Instruction is in the form of lectures, exercises and mandatory laboratory sessions.
Quantum physics and its applications: From classical physics to quantum physics, wave-particle duality, quantum mechanics, states and quantum numbers of atoms, nuclear structure, nuclear reactions, radioactivity, and elementary particles. Simple model systems, such as particle in a box and harmonic oscillators. Atoms with several electrons, chemical bonding between atoms. Special theory of relativity, relativistic momentum, relativistic energy.
Laboratory experiments on the energy levels of simple atom.

Module 3. Practical Placement 2, 7.5 ECTS cr
Students engage in the daily activities in a school, reflect on general school-related issues and plan, implement and evaluate their own physics teaching.

Module 4 Modern Experimental Physics in Education, 7.5 ECTS cr
The course is offered in the form of laboratory sessions where research issues and problems are explored experimentally. The course centres on a number of pre-planned and supervised laboratory experiments and on a supervised and independently conducted experimental project. The experiments deal with problems in the fields of quantum physics, solid state physics and nanoscience.

**Reading List**
See separate document.

**Examination**
Assessment is based on:

Module 1
All learning outcomes 1-9: written exam.

Module 2
Learning outcomes 1-6: written exam.
Learning outcome 1: Laboratory assignments and laboratory reports.

Module 3
Learning outcomes 1, 3, 4, 5, 6, 8 and 9: completed and documented practical placement.
Learning outcomes 2, 7 and 10: oral and written assignments at the university.

Attendance is required for the introduction to and the school placement component. The occasional day of absence can be completed on agreement with the module convener. Students who fail to attend more than five days will have to retake the whole module. The number of retake opportunities for the practical placement component is limited to two.

Module 4
Learning outcomes 1-3: Laboratory assignments and laboratory reports.
Learning outcomes 4-5: oral and written assignments.

**Grades**
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 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.

Teacher Education: secondary school levels