**Report – FYS3510, made simpler**

* We discussed a proposal to improve FYS3510 for high-energy particle physics (HEPP) and high-energy heavy ion (HEHI) physics for the next 2-3 years.
1. We propose to reduce both the scope and level of details of the course, in order to have more time available to treat the basics of fundamental particles and interactions needed by both HEPP and HEHI physicists at the BSc level.
	1. A textbook has been proposed [Particles and Fundamental interactions, Braibant 2012](http://www.springer.com/physics/particle%2Band%2Bnuclear%2Bphysics/book/978-94-007-2463-1): the heavy ion physicists have evaluated the nuclear physics content and found it satisfying.
	2. A brief introduction to HEHI physics based on CERN summer school student lectures complements the book
2. A revised FYS3510 course description is proposed below

**FYS3510**

# Course content

1. Basic concepts in High Energy Particle and Heavy Ion Physics: symmetries, interactions, particle exchange, scattering, cross-sections, decay rates, relativistic kinematics, and quantum numbers.
2. Leptons, quarks, hadrons. Strong interaction: colour, quantum chromo dynamics (QCD). Bound states: mesons and baryons. Deep inelastic scattering. Parton distribution functions. Weak interactions and electroweak unification, charged and neutral currents. Masses of bosons and of fermions. Spontaneous symmetry breaking and Higgs mechanism. Flavour oscillations, CP and T violation. Neutrino properties. The Standard Model and beyond, Grand Unification, Supersymmetry, Dark Matter, Antimatter.
3. Fundamental aspects of Nucleon interactions. Nuclei, nuclear stability and nuclear forces. Nuclear models. Radioactivity. Fission. Fusion. Relativistic heavy-ion collisions. Strongly interacting matter. Quark-gluon plasma.

# Learning outcome

The students are given an introduction to modern subatomic physics, with emphasis on elementary particle physics: the theoretical background and experimental support of the Standard Model of fundamental particles (fermions and bosons) and their interactions (mediated by gauge bosons). Physics of the early universe will be briefly discussed. The course explains how quarks build-up hadrons and how nucleons make up nuclei. Basic knowledge of some important properties and phenomenology of nuclei and their interactions at high energies are summarised. This course gives a foundation for advanced courses in experimental and theoretical particle physics and high-energy nuclear physics.

After the course, students are expected to know about:

1. Basic concepts behind subatomic physics
* Symmetries and conservation laws
* Relativistic kinematics, Dirac equation basics
* Collisions and decays, basic interactions and Feynman graphs
* Properties of elementary particles, quantum numbers: spin, isospin, electric and colour charges
* Leptons, quarks, gauge bosons: fermions and bosons
1. The Standard Model of electroweak and strong interactions
* Classification of matter particles and force particles
* Fundamental interactions
	+ Quantum electrodynamics (QED) and the photon
	+ Weak interactions and Electroweak unification: Neutrinos; C, P, T, CP violations; Masses and flavor oscillations; Electroweak symmetry breaking and Higgs mechanism
	+ Quantum chromo dynamics (QCD), asymptotic freedom and confinement: Coloured quarks and gluons; Hadrons: baryons and mesons.
1. Introduction to Nucleon interactions and Heavy ion collisions at High Energies
* Nuclei, nuclear stability and nuclear forces
* Nuclear models, nuclear interactions, radioactivity, nuclear fission
* Nuclear fusion in astrophysics environment
* Phase transitions; phase diagram of strongly interacting matter
* Quark-gluon plasma: phenomenology and signatures
1. Open issues and possible answers
* Grand unification, super symmetry Dark Matter, Antimatter
* The early Universe
* The Large Hadron Collider program

*Below as well we propose some changes*

**Admission**

Students at UiO must [apply for courses](http://www.uio.no/english/studies/admin/course-registration/) in StudentWeb.

**International applicants**, if you are not already enrolled as a student at UiO, please see our information about [admission requirements and procedures for international applicants](http://www.uio.no/english/studies/admission/).

**Prerequisites**

**Formal prerequisite knowledge**

In addition to fulfilling the [Higher Education Entrance Qualification](http://www.uio.no/english/studies/admission/bachelor/basic-entrance-requirements.html), applicants have to meet the following special admission requirements:

One of these:

* Mathematics R1
* Mathematics (S1+S2)

And and in addition one of these:

* Mathematics (R1+R2)
* Physics (1+2)
* Chemistry (1+2)
* Biology (1+2)
* Information technology (1+2)
* Geosciences (1+2)
* Technology and theories of research (1+2)

The special admission requirements may also be covered by equivalent studies from Norwegian upper secondary school or by other equivalent studies. Read more about [special admission requirements](http://www.uio.no/english/studies/admission/bachelor/special-requirements.html).

[FYS-MEK1110 - Mechanics](http://www.uio.no/studier/emner/matnat/fys/FYS-MEK1110/index-eng.html), [FYS1120 - Electromagnetism](http://www.uio.no/studier/emner/matnat/fys/FYS1120/index-eng.html), [FYS2130 - Waves and oscillations](http://www.uio.no/studier/emner/matnat/fys/FYS2130/index-eng.html), [FYS2140 - Quantum physics](http://www.uio.no/studier/emner/matnat/fys/FYS2140/index-eng.html),

**Recommended previous knowledge**

Knowledge corresponding to the following courses at the University of Oslo:

[FYS2160 - Thermodynamics and statistical physics](http://www.uio.no/studier/emner/matnat/fys/FYS2160/index-eng.html) and [FYS3110 - Quantum mechanics](http://www.uio.no/studier/emner/matnat/fys/FYS3110/index-eng.html).

**Overlapping courses**

10 credits.

**Teaching**

The course is given in the spring term and contains 4 hours of teaching per week. Some exercise sessions will be organized. Compulsory problems will be included (~4 series or projects)

**Examination**

At least 3 sets of compulsory problems. Normally a final oral exam will be held at the end of the semester. If more than 12 students take the exam, a written exam will be organised instead of the oral.

**Grading scale**

Grades are awarded on a scale from A to F, where A is the best grade and F is a fail. Read more about [the grading system](http://www.uio.no/english/studies/about/academic-system/grading-system/).

**Explanations and appeals**

You may:

* [request an explanation of your grades](http://www.uio.no/english/studies/admin/examinations/explanation/)
* [appeal about your grades](http://www.uio.no/english/studies/admin/examinations/appeal/)
* [make a complaint about formal exam errors](http://www.uio.no/english/studies/admin/examinations/complaint/)

**Resit an examination**

Students who can document a valid reason for absence from the regular examination may [resit an exam at the beginning of the next semester](http://www.mn.uio.no/english/studies/admin/examination/retaking-examinations/).

Re-scheduled examinations are not offered to students who withdraw during, or did not pass the original examination.

**Special examination arrangements**

If you have a disability or a health problem that entails significant inconvenience in an examination situation, you may be considered for [special examination arrangements](http://www.uio.no/english/studies/admin/examinations/special-arrangements/). Mothers who are breastfeeding may apply for extra time to complete the exam.

**Evaluation**

Feedback from our students is essential to us in our efforts to ensure and further improve the high quality of our programmes and courses. All courses are subject to continuous evaluation. At regular intervals we also ask students on a particular course to participate in a more comprehensive, periodic evaluation of this course.