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The Minimal Elements of Qualifications Standard

1. BASIC CHARACTERISTICS

1.1 Name(s) of qualification (generic + subject specific)

Bachelor of Education in Physics

1.2 Minimal volume

240 ECTS

1.3 Level

The first cycle of higher education - level 6 of the European Qualifications Framework and the Baseline Qualifications Framework (Official Gazette of BiH 31/11)

1.4 Entry routes

Eligible for admission are students who have completed a four-year secondary school.
Three criteria are taken into consideration for admission: the general criterion (the result achieved in the secondary school), the individual criterion (average grade from one to three subjects that are relevant to the respective study programme) and possibly an entrance examination (taken in one of the three subjects relevant to the respective study programme) or an interview with the candidate.

2. COMPETENCIES / LEARNING OUTCOMES

2.1 List of competencies at the level of qualification

Competencies specific to physics:

The holders of this diploma are able to:

- formulate and solve problems in general physics at the level of typical introductory courses in physics;
- plan and carry out experiments in general physics, as well as analyse experimental data and present the results of experiments;
- describe fundamental principles of modern physics and solve typical problems within the formalism of modern physics;
- use mathematical formalism and computers in order to model simple physical phenomena.

Competencies specific to the teaching of physics

The holders of this diploma are able to:

- effectively employ the curricula of primary and secondary schools in planning physics lessons;
- critically evaluate didactic potential of teaching technologies/sources of information in planning physics lessons;
- combine different teaching methods and sources of information in order to ensure interactive physics lessons;

 use experimental and mathematical methods of physics, as well as computers, in order to meet learning objectives;
 use a variety of techniques to assess knowledge and coordinate them with teaching and learning objectives;
 implement projects in physics;
 carry out action research.

Generic competencies

The holders of this diploma are expected to:

 develop problem-solving skills;
 develop research skills;
 be able to successfully communicate their ideas using various sources of information and to present them using different types of presentation;
 use computers to process data;
 be able to work independently or in a team;
 use literature in English that discusses education in physics.

2.1 Learning outcomes

(organised in Units of learning outcomes and other groups/modules, where Units have additional information, e.g. ECTS)

Unit of learning outcomes for Natural and Mathematical Sciences – 185 ECTS

General Physics, 48 ECTS

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Mathematics and Computational Physics – 53 ECTS

...

Modern Physics – 66 ECTS

...

Applied Physics – 10 ECTS

...

Geography, Astronomy and Astrophysics – 2 ECTS

...

History of Physics and Philosophy of Natural Science – 2 ECTS

…

Chemistry/Biology – 4 ECTS

…

Unit of learning outcomes for Education in Physics – 36 ECTS

Teaching Methods for Physics I

Students compare and relate the scientific and professional dimensions and the educational dimension of physics;

They analyse the role of physics in explaining the nature and the development of other sciences, engineering and technology;
They describe trends in the learning and teaching of physics in our country and globally;
They explain and interpret the cognitive cycle of physics, development of models and concepts, and contemporary concepts in the teaching of physics;
They apply different methods, forms and manner of work in the teaching of physics and take a critical view of their use;
They differentiate instruction for students with special needs;
They explain and interpret research in education, especially action research;
They realise the importance of continuous learning and professional development.

Teaching Methods for Physics II

Students plan, prepare and carry out the teaching of physics;
Students combine traditional teaching methods with active learning methods;
Students understand that experiment in physics has a predominantly cognitive role;
They can describe the content and structure as well as the process of developing a physics curriculum in terms of curricular programming and the existence of a common core programme in Bosnia and Herzegovina;
They can describe essential elements of the methods for working with children with special needs;
They can also describe other forms of educational work in physics at school and outside of school (physics competitions, leisure activities, festivals of small physics projects, etc.), as well as the organization and operation of primary and secondary schools.

Teaching Practice in Physics I

Students make appropriate use of the physics curriculum, prescribed textbooks and other teaching aids;
They describe the most important aspects of the process of curriculum development and the preparation of work plans for education in physics;
They use various forms of communication in the teaching of physics;
They produce effective written preparation for classes;
They demonstrate ability to manage pedagogical documentation;

Teaching Practice in Physics II

They prepare annual and monthly operational work plans;
They produce effective written preparation for classes;
They are trained in the use of different forms of communication in the teaching of physics;
They have completed their records of experience, observations and ideas, which they had been given during the study and through the teaching practice, and are collecting a variety of educational materials;
They carry out systematic evaluation of teaching practices as well as self-evaluation;
When performing trial and assessment classes, they employ teaching methods that are primarily focused on students.

Practicum of Teaching Methods for Physics I

Students explain the role and importance of experiments for the scientific method of understanding the reality;

As part of demonstration experiments, students can differentiate between observations and conclusions;

Students can plan, execute and interpret qualitative and quantitative experiments related to the contents of the primary school curriculum (mechanics and calorifics);

Students can independently identify ideas and create appropriate experimental designs for experiments with easily accessible materials, related to the contents of primary school curriculum (mechanics and calorifics).

Practicum of Teaching Methods for Physics II

Students can plan, execute and interpret qualitative and quantitative experiments related to the contents of the primary school curriculum (electromagnetism and optics);

Students can independently identify ideas and create appropriate experimental designs for experiments with easily accessible materials, related to the contents of primary school curriculum (electromagnetism and optics).

Students combine the use of simulations and experiments to achieve the didactic principle of vividness.

Practicum of Teaching Methods for Physics III

Students can plan in detail and execute demonstration experiments in general physics, based on the guidance provided;

Students can plan and execute experimental tasks in general physics and present the results of the experiment;

Students can independently identify ideas and create appropriate experimental designs for experiments with easily accessible materials, related to the contents of secondary school curriculum.

Students can identify in their surroundings those phenomena that could be modelled by using modern technologies.

Practicum of Teaching Methods for Physics IV

Students can solve laboratory problems in general physics;

Students can plan, conduct and present experimental projects in physics;

Students can use digital video analysis as a support to the experimental method;

Students can use sensors as a support to the experimental method.

Unit of learning outcomes for pedagogical-psychological-didactic group of courses – 12 ECTS

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Unit of learning outcomes for the group of courses primarily focused on generic skills – 3 ECTS

…

Final paper of the first cycle – 6 ECTS

ADDITIONAL

The structure of curriculum for the Bachelor of Physics as proposed by the European Physical Society:

Mechanics and Thermodynamics	Optics & Electromagnetism	Quantum Physics
20-40 ECTS credits	20-40 ECTS credits	20-40 ECTS credits
Classical mechanics • Newton's laws and conservation laws including rotation • Newtonian gravitation to the level of Kepler's laws **Thermodynamics and kinetic theory of gases** Zeroth, first and second laws of thermodynamics to include: • Temperature scales, work, internal energy and heat capacity • Entropy, free energies and the Carnot cycle • Kinetic theory of gases and the gas laws to the level of the van der Waals equation • The Maxwell-Boltzmann distribution • Statistical basis of entropy • Changes of state **Special relativity** • to the level of Lorentz transformations and the energy-momentum relationship **Advanced classical mechanics Basic** Lagrangian and Hamiltonian mechanics. **Background to quantum mechanics** • Black body radiation • Photoelectric effect • Wave-particle duality • Heisenberg's Uncertainty Principle	**Oscillations & waves** • Free, damped, forced and coupled oscillations to include resonance and normal modes • Waves in linear media to the level of group velocity • Waves on strings, sound waves and electromagnetic waves • Doppler effect **Basic optics** • Geometrical optics to the level of simple optical systems • The electromagnetic spectrum • Interference and diffraction at single and multiple apertures • Dispersion by prisms and diffraction gratings • Optical cavities and laser action **Electromagnetism** • Electrostatics and magnetostatics • DC and AC circuit analysis to the level of complex impedance, transients and resonance • Gauss, Faraday, Ampère, Lenz and Lorentz laws to the level of their vector expression **Advanced Electrodynamics and Optics** • Maxwell's equations and plane electromagnetic wave solution; Poynting vector • Polarisation of waves and behaviour at plane interfaces	**Quantum mechanics** Schrödinger wave equation to include: • Wave function and its interpretation • Standard solutions and quantum numbers to the level of the hydrogen atom • Tunnelling • First order time independent perturbation theory **Statistical mechanics** • Bose-Einstein and Fermi-Dirac distributions • Density of states and partition function **Atomic, nuclear and particle physics** • Quantum structure and spectra of simple atoms • Nuclear masses and binding energies • Radioactive decay, fission and fusion • Pauli exclusion principle, fermions and bosons and elementary particles • Fundamental forces and the Standard Model **Solid state physics** • Mechanical properties of matter to include elasticity and thermal expansion • Inter-atomic forces and bonding • Phonons and heat capacity • Crystal structure and Bragg scattering • Electron theory of solids to the level of simple band structure • Semiconductors and doping Magnetic properties of matter
Experimental & laboratory work	**Mathematics & computing**	**Optional subjects**
20-40 ECTS credits	20-40 ECTS credits	0-40 ECTS credits
Laboratory work • plan an experimental investigation; • use apparatus to acquire experimental data; • analyse data using appropriate techniques; • determine and interpret the measurement uncertainties (both systematic and random) in a measurement or observation; • report the results of an investigation and • Understand how regulatory issues such as health and safety influence scientific experimentation and observation. **Project work** The objectives of such project work will include most of the following: • investigation of a physics-based or physics-related problem • planning, management and operation of an investigation to test a hypothesis • development of information retrieval skills • carrying out a health and safety assessment • establishment of co-operative working practices with colleagues • design, assembly and testing of equipment or software generation and informed analysis of data and a critical assessment of experimental (or other) uncertainties	**Mathematics** • Trigonometric and hyperbolic functions; complex numbers • Series expansions, limits and convergence • Calculus to the level of multiple integrals; solution of linear ordinary and partial differential equations • Three-dimensional trigonometry • Vectors to the level of div, grad and curl/rot; divergence theorem and Stokes' theorem • Matrices to the level of eigenvalues and eigenvectors • Fourier series and transforms including the convolution theorem • Probability distributions **IT skills & Modelling** • Word processing packages • Data analysis and manipulation packages • Data calculation & presentation • Information searching • (A) Programming language(s) • Modelling of physical systems	A minor subject (or subjects) either related to Physics or totally unrelated. This stream may also be omitted and the credits reassigned to other streams. **Examples include:** • Chemistry • Electronics • Astronomy & Astrophysics • Medical Physics • Geophysics • Biophysics • Meteorology • Foreign language skills This theme may also include courses on generic and/ or teaching skills **Industrial Placement** Some degree programmes may include a placement in industry or other external organisation for up to one semester.

Observations: In accordance with recommendations, general physics with laboratory work should carry three times more ECTS than courses falling under modern physics. In Bosnia and Herzegovina (UNSA), courses in modern physics carry approximately 50% more ECTS than courses in general physics and laboratory work.
In addition, the recommendation is that the number of ECTS for mathematical and IT knowledge and skills should be approximately equal to the number of ECTS awarded for the development of

experimental skills. This criterion is not even close to being met in Bosnia and Herzegovina, where much more emphasis is placed on mathematical methods than on experimental methods.

3. RELEVANCE

3.1 Labour market

The diploma of a Bachelor of Education in Physics qualifies its holder to teach physics in primary and secondary vocational schools. The holders of this diploma may also find employment as laboratory technicians in primary and secondary schools and in higher education institutions.

3 Further education / progression

The student is eligible to apply for admission to the second cycle of higher education.

3 Other needs

Society's need to increase the level of scientific literacy.

4. QUALITY ASSURANCE

4.1 Working group members

Additional instructions:

- Search for examples of study programmes for acquiring similar qualifications in relevant foreign universities, or other relevant documents (Tuning, Subject benchmark statements, ...)
- Critically compare your learning outcomes with the learning outcomes in the above relevant programmes and identified documents, and, as necessary, supplement/amend your learning outcomes.
- Write about challenges during the work and how you overcame them