COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
General Physics IV	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: prof. Mikas Vengris **Other(s):**	Faculty of Physics, Quantum Electronics Dept.

Study cycle	Type of the course unit (module)
First	Compulsory

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Class	6 semester	Lithuanian/English

Requirements for students	
Prerequisites: General Physics I-III	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	150	82	68

Purpose of the course unit (module): programme competences to be developed

- The purpose of the course unit is training the attendees in the principles of quantum physics and their applications to the systems of microscopic particles, such as atoms, molecules and atomic nuclei.
- The attendees receive extended introduction to the principles of quantum mechanics and the experiments justifying the necessity of quantum description of microscopic systems.
- Atomic structure and properties are discussed with particular focus on the interaction with the electromagnetic radiation. Electron configurations, spin effects and the interaction with EM fields are discussed.
- The structure of nuclei is introduced, along with microscopic models of nuclei, interaction of nuclear radiation with matter, and the applications of nuclear physics.
- The standard model of elementary particles is presented, particle classification and the shortcomings of the model are discussed

Learning outcomes of the course unit (module)	Teaching and learning methods	Assessment methods
By the end of the course, the students are expected to be able to understand and interpret the phenomena observed in atoms and nuclei and nuclear radiation using the concepts of quantum mechanics. The students are expected to be able to apply the gained knowledge in solving problems, involving the subjects discussed in the course. (1.1, 1.2)	Lectures + problem solving exercises + homework exercises + practicum + exam	The final grade consists of the following parts 70% written exam, 20% average grade of two written tests in problem solving, 10 % practicum grade

Content: breakdown of the topics	Contact hours							Self-study work: time and assignments	
	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work placement	**Contact hours**	**Self-study hours**	**Assignments**
Development of atomic perspective. Periodic properties of atoms. Regularities of hydrogen spectrum and Ritz-Rydberg combination principle. Elementary charge and the discovery of electron. Thomson model of atom. Nuclear model of atom and Rutherford experiments.	2			1	3		**6**	**4**	Homework problem solving exercises
Development of quantum perspective. Quantization. Franck-Hertz experiments. Bohr model of hydrogen atom. Correspondence principle and its application to hydrogen atom. Spatial quantization. Stern-Gerlach experiments. Spin.	2			1	5		**8**	**6**	Homework problem solving exercises
Particle properties of radiation. Compton effect. De Broglie hypothesis. Properties of de Broglie waves. Necessity of quantum mechanical description	2			1	3		**6**	**4**	Homework problem solving exercises
Basics of quantum mechanics. Description of quantum systems using wavefunction. Superposition. Uncertainty relationships. Physical quantities and their operators. Stationary and time-dependent Schrödinger equation. Calculation of observables.	2			1			**3**	**2**	Homework problem solving exercises
Hydrogen atom. Problem formulation and solutions of Schrödinger equation for H atom. Energy levels and quantum numbers in H atom. Shape of the wavefunction and electron probability distribution in H-like atom. Energy levels of alkali metals. Selection rules. Spectra of alkali metals. Vector model of single-electron atom. Spin-orbit interaction. Fine structure of spectral lines.	3			1	3		**7**	**6**	Homework problem solving exercises
Multi-electron atoms. Addition of angular momenta. Coupling types. Energy levels and spectrum of helium atom. Approximate description of atoms using quantum numbers *n* and *l* in multi-electron atoms. Electron shells and their filling. X-ray spectra and their origin.	2			1	3		**6**	**4**	Homework problem solving exercises
Atoms in magnetic fields. Total magnetic moment of one-electron atom. Anomalous Zeeman effect. Paschen-Back effect. Hyperfine structure of spectral lines. Magnetic resonance.	2			1	3		**6**	**4**	Homework problem solving exercises
Structure and properties of molecules. Principles of Chemical bond formation. Chemical bond in H_2^+ molecular ion. Chemical bond in KCl molecule. Motion in molecules. Rotational energy levels and spectra. Vibrational energy levels and spectra.	2			1			**3**	**2**	Homework problem solving exercises

Electronic spectra of molecules.									
General properties of nuclei. Development of nuclear physics and terminology. Nuclear binding energy. Semiempirical (von Weizsäcker) formula for binding energy. Nuclear radii. Nuclear spin and magnetic moment.	2			1	3		**6**	**4**	Homework problem solving exercises
Radioactivity. Types of radioactivity. Laws of radioactive decay. α decay. β decay. Weak interaction and leptons. Neutrino mass problem and experimental detection of neutrinos. γ radiation from nuclei.	2			1	3		**6**	**4**	Homework problem solving exercises
Microscopic models of nuclei. Collective (liquid drop) models. Shell model of nucleus. Classification of nuclear energy levels and their filling with nucleons. Interpretation of nuclear spins. Generalized models of nuclei.	2			1			**3**	**2**	Homework problem solving exercises
Interaction of ionizing radiation with matter. Propagation of heavy charged particles. Propagation of light charged particles. Propagation of γ radiation.	2			1	6		**9**	**6**	Homework problem solving exercises
Particle accelerators. Linear accelerators. Cyclic accelerators. Stationary targets versus head-on beams.	2			1			**3**	**2**	Homework problem solving exercises
Nuclear reactions. Definitions and notations. Compound nucleus. Direct nuclear reactions. Fission of nuclei. Chain reaction and nuclear reactors. Fusion of nuclei. Nuclear reactions in stars	2			1			**3**	**2**	Homework problem solving exercises
Cosmic radiation. Primary cosmic rays. Propagation of cosmic rays in atmosphere. Van Allen radiation belts of Earth.	1			1			**2**	**2**	Homework problem solving exercises
General properties of elementary particles. Fundamental interaction forces and their carrier particles. Classification of elementary particles. Conservation laws and symmetries. Quark model of hadrons. Standard model.	2			1			**3**	**4**	Homework problem solving exercises
Exam	2						**2**	**10**	
Total	**34**			**16**	**32**		**82**	**68**	

Assessment strategy	**Weigh t,%**	**Deadline**	**Assessment criteria**
Practicum	10 %	End of semester	The quality of performance of assigned tasks is evaluated (fraction of assignments completed, achievement of required results). The performance, presentation and defense of practica is graded by a mark, which contributes 10% to the final grade.
Problem solving exercises	20%	Entire semester	Two problem-solving tests are taken during the semester. Their average grade contributes 20% to the final grade.
Exam	80 %	Exams session	Questions and answers from different topics discussed in the course unit (>30 questions). Correctness of answers is evaluated.

Author	**Year of**	**Title**	**Issue of a periodical**	**Publishing place and house or web link**

	public ation		or volume of a publication	
Compulsory reading				
1.A. Poškus	2008	Atomo fizika ir branduolio fizikos eksperimetiniai metodai		Vilniaus universiteto leidykla
2. C.J.Foot	2005	Atomic Physics		Oxford University Press
3. Kenneth S. Krane	1987	Introductory Nuclear Physics		John Wiley and Sons
4. I.E. Irodov	1983	Problems in Atomic and Nuclear Physics		Mir
Optional reading				
1. Leon van Dommelen	2015	Quantum Mechanics for engineers.		http://www.eng.fsu.edu/~dommelen/quantum/style_a/index.html