UNIVERSITY OF SARAJEVO

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

CURRICULUM FOR THE ACADEMIC YEAR 2018/2019

PHYSICS EDUCATION

SECOND CYCLE

GENERAL INFORMATION ABOUT THE STUDY PROGRAM

NAME OF THE STUDY PROGRAM:	Physics Education
TYPE OF THE STUDY PROGRAM:	University Study Program
LEVEL OF THE STUDY PROGRAM:	Second Cycle of Higher Education
GOALS OF THE STUDY PROGRAM:	● To acquire fundamental knowledge and skills necessary for doing physics education research, ● To improve knowledge and competences in the fields of general and modern physics, as well as in the field of physics education, ● To further develop knowledge and skills of implementing the active learning approach in physics classes, ● To further develop skills of using experimental and mathematical methods, as well as computers in physics, ● To develop communicational, social, mathematical, informatics and research skills.
PROVIDER OF THE STUDY PROGRAM:	University of Sarajevo, Faculty of Science, Department of Physics
SCIENTIFIC AREA OF THE STUDY PROGRAM:	Physics (subfield: Physics Education)
STRUCTURE OF THE STUDY PROGRAM:	The classes are delivered in the form of lectures, seminars, recitations, labs/practices. The focus is on didactic analysis and implementation of the active learning approach in physics classes. Elective courses are offered in the 1st, as well as in the 2nd semester. A total of 9 ECTS credits are allocated to elective courses and 20 credits are allocated to preparation and defense of the final thesis.
DURATION OF THE STUDY PROGRAM:	The study program lasts for 1 year (2 semesters).
LANGUAGE OF THE STUDY PROGRAM:	Bosnian/Croatian/Serbian
ENTRY ROUTES AND SELECTION CRITERIA:	All individuals who have completed the first cycle of higher education in the field of physics or related disciplines are eligible to apply for the 2nd cycle study program „Physics Education“. Applicants are ranked according to their grade point average, as well as according to other criteria set out in the public call for applications.
INFORMATION ABOUT THE QUALIFICATION:	Qualification Title: Master of Science in Physics Education Level of the Qualification: Second cycle of higher education; Level 7 in Basis of Qualifications Framework in Bosnia and Herzegovina
PROFESSIONAL STATUS:	The Master of Science in Physics education degree qualifies the holder to teach physics in primary and secondary schools. Additionally, the holder is qualified for working as advisor in the Ministry of Education and in various agencies devoted to assuring quality of education, as well as in other institutions that employ masters of science in physics education.

ACCESS TO FURHER STUDY:	The holder of the Master of Science in Physics Education degree is eligible to apply for admission to third cycle of higher education programs in the field of physics and related disciplines.
ASSESSMENT AND GRADING PRACTICES:	Students are continuously assessed throughout the semester. Thereby, all their activities are awarded with a number of points. In most courses, students can earn points by performing activities such as: homework, seminar papers, partial exams and final exams. At the beginning of each academic year the Faculty Council adopts the grading schemes for all offered courses.
QUALITY ASSURANCE:	Quality assurance of the study program Physics Education is based on students' evaluation of teachers and teaching assistants, as well as the evaluation of each individual course. Evaluation is carried out after each semester, and students have the opportunity to express their opinions on the course contents, students' workload in the course, the quality of teaching and the organization of exams. Obtained results are analyzed and reports are delivered to teachers for each course individually. Based on course evaluation feedback, teachers are expected to continuously improve the quality of their courses.
INTENDED LEARNING OUTCOMES AT THE LEVEL OF THE STUDY PROGRAM:	**Learning outcomes in the field of Physics** The diploma holder is able to: ● Formulate and solve advanced problems in general physics, ● Plan and execute relatively complex physics experiments, as well as to analyse experimental data and communicate the results, ● Explain fundamental principles of modern physics and solve typical problems within the formalism of modern physics, ● Use mathematics and computers for purposes of modelling physical phenomena. **Learning outcomes in the field of Physics teaching** The diploma holder is able to: ● Evaluate critically the didactic potentials of various sources of information and teaching resources in general when planning physics classes, ● Combine different teaching methods and resources with the aim of ensuring the interactivity of physics classes, ● Use experimental and mathematical methods of physics as well as computers for purposes of fulfilling the learning objectives, ● Use different assessment techniques, and align them with teaching methods and learning objectives, ● Implement projects in physics classes, ● Evaluate critically the different active learning approaches to teaching physics, ● Implement differentiated instruction efficiently,

	Learning outcomes related to research skills The diploma holders is able to: ● Evaluate relatively simple research design within the context of physics education research, ● Conduct different types of action research, ● Use efficiently the think-aloud technique for purposes of exploring the students' learning processes, ● Create simple research plans for a variety of research designs. **Learning outcomes - generic** The diploma holder: ● Systematic solve problems and conduct investigations, ● Successfully present her/his ideas efficiently, using various media and representations, ● Use computers for purposes of data processing, ● Is able to work independently as well as in a team, ● Use reference sources in English related to physics education.
ELECTIVE COURSES:	At the beginning of each academic year the Department of Physics Council adopts a list of potential elective courses and decides about implementation of these courses based on actual human and material resources, as well as based on students' needs and interests.
COMPLETION OF THE STUDY PROGRAM:	For successful completion of the study program, the students have to pass all the exams, write and defend the final thesis and acquire a minimum of 60 ECTS credits.

LIST OF MANDATORY AND ELECTIVE COURSES

PHYSICS EDUCATION II CYCLE – 4+1

COURSES	CODES	SEMESER I L+E	SEMESER II L+E	ECTS POINTS
Physics education III	**PED9611**	3+2		6
Selected topics in Psychology	**POT9411**	2+1		4
Educational research for physicists	**PED9621**	3+2		6
Selected topics in contemporary physics	**PTH9641**	3+2		6
An introduction to the philosophy of physics	**PHY9311**	2+0		3
Elective course				5
Total ECTS points				**30**
Physics education IV	**PED0611**		3+2	6
Elective course				4
Master's thesis				20
Total ECTS points				**30**

LIST OF POSSIBLE ELECTIVE COURSES ON THE II CYCLE OF STUDY – 4+1

Elective course\Semester	**CODES**	**I L+E**	**II L+E**	**(E)CTS POINTS**
Physics of ionizing radiation I	**PAP7521**	2+2		5
Medical radiation physics I	**PAP7531**	2+2		5
Physics of the human body	**PHY9511**	3+1		5
Active Learning Strategies in Physics Teaching	**PED0411**		2+2	4
Advanced course of optics	**PTH6431**		2+1	4
With the appropriate decision of the Council of Physics Department, every academic year the list of possible elective subjects can be supplemented by some of the subjects that are part of the adopted curricula at University of Sarajevo.				

<table>
<tr><td rowspan="2">Study program</td><td colspan="2">Level of the study program</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Name of the study program</td><td colspan="2">Physics Education</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS EDUCATION III</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PED9611</td><td>I</td><td>MANDATORY</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Vanes Mešić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to further develop students' understanding about didactical specifics of learning and teaching mechanics and thermodynamics at the level of primary and secondary school.
Intended learning outcomes:
1. Describe common students' difficulties in learning mechanics and thermodynamics.
2. Identify potential sources of students' difficulties in learning mechanics and thermodynamics.
3. Identify and/or create approaches to overcoming students' difficulties in learning mechanics and thermodynamics.
4. Solve challenging (conceptual and quantitative) physics problems.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Learning and teaching about kinematics of one-dimensional motion. Learning and teaching about kinematics of two-dimensional motion. Learning and teaching about the concept of force and Newton's laws of motion. Learning and teaching about applications of Newton's laws of motion. Learning and teaching about circular motion and the concept of gravity. Learning and teaching about rotational motion, static equilibrium and elasticity. Learning and teaching about momentum. Learning and teaching about energy, work and power. Learning and teaching about the energy concept in various contexts. Learning and teaching about heat phenomena. Learning and teaching about fluids. Learning and teaching about the concept of oscillation. Learning and teaching about the wave concept. Learning and teaching about superposition of waves and standing waves.</td></tr>
</table>

<table>
<tr><td colspan="2">Student workload (hours)</td><td colspan="2">Grading</td></tr>
<tr><td>Lectures and Exercises</td><td>75</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>50</td><td>Partial exam</td><td>40</td></tr>
<tr><td>Assignments</td><td>20</td><td>Seminar paper</td><td>20</td></tr>
<tr><td>Other</td><td>5</td><td>Final exam</td><td>40</td></tr>
<tr><td>Total</td><td>150</td><td></td><td></td></tr>
<tr><td colspan="2"></td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">1. Muratović, H., Mešić, V. (2009). Didaktičko-metodički prilozi nastavi fizike. Sarajevo: Prirodno-matematički fakultet.
2. Arons, A. B. (1997). Teaching Introductory Physics. New York: John Wiley & Sons, Inc.
3. Knight, R. (2004). Five Easy Lessons: Strategies for Successful Physics Teaching. San Francisco: Addison-Wesley.
4. Selected articles from physics education journals.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Study program	Level of the study program	**Second cycle studies**
	Name of the study program	**Physics Education**

Course name	**SELECTED TOPICS IN PSYCHOLOGY**

Course ID	Semester	Course ID	ECTS credits	L+E
POT9411	**I**	**MANDATORY**	**4**	**2+1**

Nosilac programa	**Prof. dr. Nermin Đapo**
Aims and intended learning outcomes	Acquisition of basic knowledge in Psychology and development of skills important in the process of teaching. Intended learning outcomes ● Knowledge of psychological aspects of learning and teaching. ● Application of acquired knowledge in teaching. ● Integration of acquired knowledge with knowledge in pedagogy.

Course content

Basics of Psychology. Psychology and other sciences.
Learning. Theory of learning in school context.
Memory. Structure and process of memory. Improvement of memory. Organization of declarative and procedural knowledge.
Thinking. Problem solving. Creativity.
Intelligence. Types of intelligence. Individual differences in intelligence.
Motivation. Motivation in school context.
Theory of emotion. Emotion in school context.
Theory of personality. Personality development. Individual differences in personality and cognition in school children.
Developmental psychology. Biological and environmental factors of development. Ecological model of development.
Process of communication. Interpersonal communication. Communication in the classroom.
Teaching. Methods of teaching.
Groups. Structure and process of group. Classroom as a group.
Stress in school. Teacher stress.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Bodovi
Exam preparation	30	Classroom activities	10
Assignments	25	Seminar paper	40
Total	100	Final exam	50
		Toala	100

Literature

Sternberg, R.J. (2005). *Kognitivna psihologija.* Naklada Slap. Jastrebarsko.
Zarevski, P. (1994). *Psihologija pamćenja i učenja*, Naklada Slap. Jastrebarsko.
Rathus, S. A. (2000). *Temelji psihologije*. Naklada Slap. Jastrebarsko.
Sawyer, R.K. (Ed.). (2006). *The Cambridge Handbook of the Learning Sciences*. Cambridge University Press.
Slavin, R.E. (2006) *Educational Psychology: Theory and Practice* (Edition 8), Allyn & Bacon, Boston.

Remarks

<table>
<tr><td rowspan="2">Study program</td><td colspan="2">Level of the study program</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Name of the study program</td><td colspan="2">Physics Education</td></tr>
<tr><td>Course name</td><td colspan="4">EDUCATIONAL RESEARCH FOR PHYSICISTS</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PED9621</td><td>I</td><td>MANDATORY</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Vanes Mešić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to develop students’ competence to plan, conduct and evaluate educational research.
Intended learning outcomes:
1. Describe the defining features of the qualitative, quantitative and mixed research paradigm in educational research.
2. Describe effective approaches to identifying research problems and reviewing relevant literature.
3. Explain the most important concepts of descriptive and inferential statistics and perform simple calculations.
4. Identify the statistical tests that are appropriate for testing the given hypotheses.
5. Evaluate the assessment instruments that are often applied in physics education research.
6. Describe the various quantitative and qualitative methods that are used in physics education research and discuss the potential of given research designs.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Nature of research in physical and human sciences. Modern approaches to physics education research. Research problem. Location and review of relevant literature. Hypothesis in quantitative research. Descriptive statistics. Sampling and inferential statistics. Assessment instruments – examples from physics education research. Validity and reliability. Experimental research – examples from physics education research. Experimental research designs. Ex post facto research. Correlational research – examples from physics education research. Survey research. Large-scale studies in mathematics and science education research. Defining and designing qualitative research. Types of qualitative research. Analysing and reporting qualitative research – examples from physics education research. Action research.</td></tr>
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<table>
<tr><td colspan="2">Student workload (hours)</td><td colspan="2">Grading</td></tr>
<tr><td>Lectures and Exercises</td><td>75</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>50</td><td>Partial exam</td><td>40</td></tr>
<tr><td>Assignments</td><td>15</td><td>Research proposal</td><td>20</td></tr>
<tr><td>Other</td><td>10</td><td>Final exam</td><td>40</td></tr>
<tr><td>Total</td><td>150</td><td></td><td></td></tr>
<tr><td colspan="2"></td><td>Total</td><td>100</td></tr>
</table>

Literature

1. Mužić, V. (2004). *Uvod u metodologiju istraživanja odgoja i obrazovanja*. Zagreb: Educa.
2. Kelly, A. E., & Lesh, R. A. (Eds.). (2012). *Handbook of research design in mathematics and science education*. Routledge.
3. Krüger, D., Parchmann, I., & Schecker, H. (2014). *Methoden in der naturwissenschaftsdidaktischen Forschung*. Berlin: Springer.
4. Ary, D., Jacobs, L. C., Irvine, C. K. S., & Walker, D. (2018). *Introduction to research in education*. Boston: Cengage Learning.
5. Selected articles from physics education journals.

Remarks

Program	Level of studies		**Second cycle studies**	
	Program name		**Physics Education**	
Course name	**SELECTED TOPICS IN CONTEMPORARY PHYSICS**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH9641	**I**	**MANDATORY**	**6**	**3+2**
Lecturer	**Prof. dr. Azra Gazibegović - Busuladžić**			
Aims and expected learning outcomes	The aim of this course is to give the students of educational physics more detailed knowledge of the selected parts of contemporary theoretical physics. After the successful completion of the course student: Knows the basics of the dynamics of nonlinear systems; Knows the principles of the accelerator and particle detector; Knows the elements of the Standard model and modern theories beyond it; Knows the elements of the General Relativity and its results; Knows the basics of cosmology.			

Course content

Nonlinear dynamics and chaos: Dynamics of dissipative systems, attractors. Bifurcations. Fractals and fractal dimensions.
Stability of the atomic nucleus. Nuclear models.
Accelerators and detectors. Elementary particles and fundamental interactions. Standard model - leptons and quarks, vector bosons.
Space-time and internal symmetry, conservation laws, quantum numbers. Discrete symmetry, PCT theorem. Oscillations of neutrinos. Need for color, QCD. Spontaneous symmetry violation, Higgs boson.
Physics beyond the Standard Model: Great unification, supersymmetry, string theory, quantum gravity.
The influence of particle physics on the development of society and medicine.
Cosmic rays. Getting information about the universe - optical, gamma, X, neutrinos astronomy.
Classification of stars. Expansion of the universe, Hubble's constant.
Basic solutions of Einstein field equations. Gravitational waves. Singularities, black holes, Big Bang theory. Thermodynamics of the early universe. Nucleosynthesis, the formation of structures in the universe. Inflation. Dark matter.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	75	Partial exams	60
Total	150	Final exam	40
		Total	100

Literature

1. C. Grupen, Astroparticle Physics, Springer-Verlag 2005
2. Material from the web-site "e-nastava"

Additional readings:

1. M. R. Belić, Deterministički haos, Sveske fizičkih nauka, III (3), Beograd, 1990
2. D. T. Ferbel, Introduction to Nuclear and Particle Physics, Second Edition, World Scientific 2003
3. B. R. Martin, G. Show, Particle physics, John Wiley and sons, 1995

Remarks

The student must win a minimum of 55% of the points on the partial exams to have the right to enter the final exam.

Study program	Level of the study program	**Second cycle studies**
	Name of the study program	**Physics Education**
Course name	**AN INTRODUCTION TO THE PHILOSOPHY OF PHYSICS**	

Course ID	Semester	Course status	ECTS credits	L+E
PHY9311	**I**	**MANDATORY**	**3**	**2+0**

Lecturer	**Prof. dr. Vanes Mešić**
Aims and intended learning outcomes	The aim of this course is to further develop students' understanding of historical-philosophical aspects of human thought about physical reality. Intended learning outcomes: 1. Analyse the evolution of prominent ideas about the physical world throughout the history of humankind. 2. Interpret the most important aspect of epistemology of physics. 3. Analyse the relationship between physics and philosophy.

Course content

Ideas about physical reality in the antique era. Elementalism – Thales, Democritus; Ideas about representing the physical world through numbers – Pythagoras, Plato. Concept of force in the antique – Empedocles, Aristotle. The relationship between reality and its conceptual representation – Aristotle, Archimedes. Symmetries – Kepler. Development of language of kinematics – Galileo Galilei, Newton. Geometry and the concept of force – Descartes, Leibniz. Comparing physical ideas in early mediaeval Europe and in the antique era. Physics of the 19th and 20th century – loss of intuitiveness. Analogies between mechanics and electrodynamics.
Concept of physical field – physics and geometry. Development of quantum physics. Theory of everything.

Development of physical concepts and theories. Criteria for evaluation of scientific theories. Relationship between different theories. Importance of analogies in physics. Modern meaning of the causality concept. Causality and mathematisation of physics. Mereological approach to describing and explaining physical realities. Quest for causal mechanisms. The holistic approach to describing and explaining physical realities. Relationship between different approaches to explaining physical realities. Physics and empiricism. Setting hypotheses and developing models in physics. The role of the experiment in physics. Unity of physics. Relationship between physics and other sciences.

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	25	Partial exam	40
Assignments	15	Seminar paper	20
Other	5	Final exam	40
Total	75		
		Total	100

Literature

1. Lelas, S., Vukelja, T. (1996). *Filozofija znanosti*. Zagreb: Školska knjiga.
2. Torretti, R. (1998). *The Philosophy of Physics*. Cambridge: CUP.
3. Sieroka, N. (2014). *Philosophie der Physik: Eine Einfuehrung*. Muenchen: C.H. Beck.
4. Selected articles from physics education journals.

Remarks

<table>
<tr><td rowspan="2">Study program</td><td colspan="2">Level of the study program</td><td colspan="2">Second cycle studies</td></tr>
<tr><td colspan="2">Name of the study program</td><td colspan="2">Physics Education</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS EDUCATION IV</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PED0611</td><td>II</td><td>MANDATORY</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Vanes Mešić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to further develop students' understanding about didactical specifics of learning and teaching electromagnetism, optics and modern physics at the level of primary and secondary school.
Intended learning outcomes:
1. Describe common students' difficulties in learning electromagnetism, optics and modern physics.
2. Identify potential sources of students' difficulties in learning electromagnetism, optics and modern physics.
3. Identify and/or create approaches to overcoming students' difficulties in learning electromagnetism, optics and modern physics.
4. Solve challenging (conceptual and quantitative) physics problems.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Learning and teaching about wave optics. Learning and teaching about ray optics. Learning and teaching about optical instruments. Learning and teaching about electric fields and electric force. Learning and teaching about the electric potential. Learning and teaching about electric current and electric resistance. Learning and teaching about electric circuits. Learning and teaching about the magnetic field and magnetic force. Learning and teaching about electromagnetic induction and waves. Learning and teaching about alternating current. Learning and teaching about relativity. Learning and teaching about quantum physics. Learning and teaching about atomic and molecular physics. Learning and teaching about nuclear physics.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	50	Partial exam	40
Assignments	20	Seminar paper	20
Other	5	Final exam	40
Total	150		
		Total	100

Literature

1. Muratović, H., Mešić, V. (2009*). Didaktičko-metodički prilozi nastavi fizike*. Sarajevo: Prirodno-matematički fakultet.
2. Arons, A. B. (1997). Teaching Introductory Physics. New York: John Wiley & Sons, Inc.
3. Knight, R. (2004). Five Easy Lessons: Strategies for Successful Physics Teaching. San Francisco: Addison-Wesley.
4. Selected articles from physics education journals.

Remarks

<table>
<tr><td>Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle studies</td></tr>
<tr><td></td><td colspan="2">Program name</td><td colspan="2">Physics Education</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS OF IONIZING RADIATION I</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PAP7521</td><td>I</td><td>ELECTIVE</td><td>5</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. dr. Benjamin Fetić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to deepen students' basic knowledge of nuclear physics as a base for further study of medical radiation physics.
After completing the course, students should:
- Understand the basis of the processes at atomic nucleus level and conditions for atomic nucleus stability;
- Be familiar with mechanisms of ionizing radiation emission and its application in technology and medicine.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Structure of the atomic nucleus. Nuclear forces. Conditions for nuclear stability. A liquid drop model, Bethe-Weizsacker formula. Testing beta stability by Bethe-Weizsacker model. Radioactive elements Tc (technetium) and Pm (promethium). Shell model, magic numbers. Other nuclear models.
Radioactivity: The law of radioactive decay. Decay series. Secular equilibrium compound decay, transient equilibrium compound decay. Complex radioactive decay. Natural and artificial sources of ionizing radiation. Production and use of radionuclides.

Alpha disintegration: The alpha decay theory. WBK method. Geiger-Nuttall's rule.
Beta disintegration: Beta plus and beta minus decay, conservation laws for beta disintegration. Violation of parity. Fermi's theory of beta decay. Electron capture (EC).
Gamma decay: basics of the theory of gamma radiation. Isomeric transitions. Forbidden transitions.
Internal conversion (IC) and Auger electrons.
Nuclear reactions. Nuclear reaction cross-section. Nuclear fission. Nuclear fusion.
Production and properties of X-radiation. X-ray spectrum: Characteristic and continuous X-radiation.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	55	Midterm exams	40
Assignments	10	Seminar	20
Total	125	Final exam	40
		Total	100

Literature

1. D. Samek,L. Saračević , A. Lagumdžija, Fizika jonizirajućih zračenja, Veterinarski fakultet Univerziteta u Sarajevu, 2010
2. A. Lagumdžija, D. Samek, R. Musemić, Fizika jonizirajućih zračenja u primjeni, PMF Univerziteta u Sarajevu 2010
3. Corresponding material from the web-site "e-nastava" and notes from the lectures.
Additional readings:
1. H. Johns, J. Cunningham, The physics of radiology, Charles C Thomas Publisher, Springfield, Illinois 1983
2. E. B. Podgorsak, Radiation oncology physics, IAEA 2005
3. S. N. Ahmed, Physics & engineering of radiation detection, 2nd edition, Elsevier 2015

Remarks

A student must win a minimum of 22 points on partial exams in order to enter the final exam. To successfully pass, at the final exam the students must score at least 22 points, and the total score must be at least 55 points.

Program	Level of studies		**Second cycle studies**	
	Program name		**Physics Education**	
Course name	**MEDICAL RADIATION PHYSICS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP7531	**I**	**Elective**	**5**	**2+2**
Lecturer	**Doc. Dr. Adnan Beganović**			
Aims and intended learning outcomes	Aim: Adopt basic knowledge in medical radiation physics and radiation protection. Outcomes: to understand the basics of dosimetry of ionizing radiation and radiation biology; master and understand the basic methods and techniques used in modern radiotherapy, diagnostic radiology and nuclear medicine, and apply them in medical practice; understand the basic principles of radiation protection, and apply them consistently in medical practice.			

Course content

1. Introduction: The subject of study and the role of medical radiation physics in modern medicine; Exercises.
2. Interaction of ionizing radiation with matter: The charged particles; Stopping power for heavy charged particles; Necessary corrections for electrons and positrons; The theory of multiple collisions and the application of the transport of charged particles; Bremsstrahlung and emission stopping power; Energy and angular distribution of X-ray radiation formed on a thin and thick target; Deposit of energy for heavy charged particles and electrons; Absorption of monoenergetic electron beam; Variations in energy and angular distribution of electrons with depth; Calculation of medium and most probable energy; Photons; Energy balance in the case of photoelectric effect, coherent scattering, incoherent scattering and production of electron-positron pairs on the nucleus and in the electron field; Variations of the effective cross-section depending on energy and atomic number; Energy and angular distribution of secondary photons and electrons; Attenuation curves; Half-value layer (HVL) and the mean free path; Neutrons; Absorption of neutrons; Q-relation; Neutron resonance; Deposit of neutron energy depending on depth; Exercises
3. Basics of the dosimetry of ionizing radiation: The subject of the study is the dosimetry of ionizing radiation and the dosimetric quantities; Measurement units in the dosimetry; Effective atomic number; The concept of KERMA and absorbed dose; Electronic equilibrium; Exposure; Finding absorbed dose in free space (Bragg-Gray's theory); Absorbed dose in the phantom; A relationship that connects the energy flux and exposure; Conversion of exposure to absorbed dose; Exercises
4. High-energy machines for the production of ionizing radiation: Introduction; Medical linear accelerator; Isotope machines; Cyclotron; High-energy particles in radiotherapy; Exercises.
5. Radiation biology: Cell structure; Genetic code; Chromosomes and cell division; The effect of radiation on the cell; Deterministic and stochastic effects; Mutations; Survival curve; Whole body irradiation; LD_{50} and LD_{100}; Acute radiation syndrome; Radiation risk and its evaluation; Exercise.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	50	Midterm	45
Other	5	Final	45
Total	125	Activity	10
		Total	100

Literature

1. Dance DR, Christofides S, Maidment ADA, McLean ID, Ng KH, editors. Diagnostic Radiology Physics: A Handbook for Teachers and Students. Vienna, Austria: IAEA; 2014.
2. Pdgoršak EB, editor. Review of Radiation Oncology Physics: A Handbook for Teachers and Students. Vienna, Austria: IAEA; 2005.
3. Bailey DL, Humm JL, Todd-Pokropek A, van Aswegen A, editors. Nuclear Medicine Physics: A Handbook for Teachers and Students. Vienna, Austria: IAEA; 2014.
4. Johns HE, Cunningham JR. The Physics of Radiology. 4th ed. Springfield, IL: Charles C Thomas; 1983.

Remarks

Exercises are performed at the Clinical Centre of Sarajevo University.

Program	Level of studies	**Second cycle**
	Program name	**Physics –Educational Physics**
Course name	**PHYSICS OF THE HUMAN BODY**	

Course ID	Semester	Course status	ECTS credits	L+E
PHY9511	**IX**	**ELECTIVE**	**6**	**3+1**

Instructor	**Prof. dr. Mustafa Busuladžić**
Aims and expected learning outcomes	The goal of this course is to provide an introduction to the physics of the human body. The laws of physics are used to explain some bodily functions such as the mechanics of muscles, fluid mechanics of blood, hearing and acoustic properties of the ears, heat and energy, vision optics, and electrical signalling. At the end of the course the student should be able to: -explain the biomechanics of the body; -use the principles of physics to explain the functioning of cardiovascular and pulmonary systems; -describe the electrical conduction system of the nerves, the brain and the heart; -apply the principles of physics to describe the functions of the visual and auditory system; -solve basic conceptual and numerical problems related to the human body.

Course content

Terminology, modeling, and measurement. Mechanics. Muscle and Forces. Categories of forces. Some effects of gravity on the body. Electrical forces in the body. Frictional forces. Newton's laws of motion. Physiological applications of Newton's laws. Torque and equilibrium. Classes of levers and physiological applications. Energy, heat, work, and power the body. Transport of energy and matter. Heat and laws of thermodynamics. Heat losses from the body. Membranes in the living organisms. Diffusion and osmosis. Physics of the lungs and breathing. The ideal gas laws. The basic parameters of the respiratory system at the rest. Pressure-volume relationship of the air in the lungs. Physics of the alveoli. The breathing mechanism. The work of breathing. Fluids. Flow of an ideal dynamic fluid. Viscosity. Physics of the cardiovascular system. Work done by the heart. Basic issues in blood flow. Blood pressure and its measurement. Vibrations and waves. Sound and speech. Sound intensity and sound intensity level. Physics of the ear and hearing. The hearing range of the human ear. Force and pressure amplification in the middle ear. Electromagnetism. Electricity within the body. The nerves as an electrical system. Electrochemical processes in nerves. The flow of charges. Stimulated nerve impulses. Electrocardiography. Physics of the eyes and vision. Ray optics. Applications in optometry and ophthalmology. The Eye. Defects of the eye. Wave optics. Diffraction effects on the eye.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	90	Course Test	50
Total	150	Final Exam	50
		Total	100

Literature

1. Lecture Notes.
2. S. Stanković, Fizika ljudskog organizma, prvo izdanje, PMF, Novi Sad, 2006.
3. J. R. Cameron, J. G. Skofronick, R. M. Grant, Physics of the Body, revised second ed., Medical Physics Publishing, Madison Wisconsin, 2017.
4. M. Zinke-Allmang et al., Physics for the life sciences, third ed., Nelson education, Toronto, 2017.
5. P. Davidovits, Physics in biology and medicine, fourth ed., Academic Press, London, 2013.
6. K. Franklin et al., Introduction to Biological Physics for the health and life sciences, first ed., Wiley, New York, 2010.

Remarks

Continuous knowledge and skills assessment will be carried out through midterm exams (written tests). Final examination can also be oral exam. The successful completion of the course implies achieving at least 55% of the total number of points in both the partial and final exam.

<table>
<tr><td rowspan="2">Study program</td><td colspan="2">Level of the study program</td><td colspan="2">Second cycle studies</td></tr>
<tr><td colspan="2">Name of the study program</td><td colspan="2">Physics Education</td></tr>
<tr><td>Course name</td><td colspan="4">ACTIVE LEARNING STRATEGIES IN PHYSICS TEACHING</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PED0411</td><td>II</td><td>ELECTIVE</td><td>4</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Vanes Mešić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to further develop the students’ abilities to use active learning strategies in physics teaching.
Intended learning outcomes:
1. Evaluate the pedagogic opportunities of various teaching strategies.
2. Identify the factors that moderate the effectiveness of active learning strategies in physics teaching.
3. Prepare and conduct lessons based on different variants of active learning approaches in physics teaching.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Basic principles of cognitive psychology. Model of a teaching environment. Role of the teacher in a teaching environment that promotes active learning. Use of active learning strategies in different teaching formats. Overview of most important active learning approaches in physics teaching. Inquiry-based teaching. Case studies and problem-based learning. Project-based learning. Assessing students’ learning outcomes in active learning classrooms.</td></tr>
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<table>
<tr><td colspan="2">Student workload (hours)</td><td colspan="2">Grading</td></tr>
<tr><td>Lectures and Exercises</td><td>60</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>20</td><td>Partial exam</td><td>30</td></tr>
<tr><td>Assignments</td><td>10</td><td>Preparing and conducting lessons</td><td>30</td></tr>
<tr><td>Other</td><td>10</td><td>Final exam</td><td>40</td></tr>
<tr><td>Total</td><td>100</td><td></td><td></td></tr>
<tr><td colspan="2"></td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">1. Mešić, V. (2015). Uvod u didaktiku fizike. Sarajevo: Prirodno-matematički fakultet.
2. Mattes, W. (2007). Nastavne metode: 75 kompaktnih pregleda za nastavnike i učenike. Zagreb: Naklada Ljevak.
3. Michael, J.A., & Modell, H.I. (2003). Active learning in secondary and college science classrooms. Mahwah, NJ: Lawrence Erlbaum.
4. Bass, J. L., Contant, T. L., & Carin, A. A. (2014). Teaching Science Through Inquiry and Investigation. Boston: Pearson.
5. Selected articles from physics education journals.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Program	Level of studies	**Second cycle studies**
	Program name	**Physics Education**
Course name	**ADVANCED COURSE OF OPTICS**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH6431	**II**	**ELECTIVE**	**4**	**2+1**

Lecturer	**Prof. dr. Azra Gazibegović - Busuladžić**
Aims and intended learning outcomes	Aim of the course is to deepen students' knowledge and understanding of general optics, considering more realistic optical models and EM wave properties. After successfully completed course, student will: understand and use connection between electromagnetism and optics, Fresnel's formulas, matrix formulation of ray optics; describe light interference from realistic finite-size sources, multiple-beam interference, diffraction, and solve related problems; describe propagation of light in anisotropic media and it applications.

Course content

Electromagnetic Waves: properties, superposition, polarization. Averaging. Flux Densities of Energy and Momentum of Electromagnetic Waves. Light Pressure. Photometric Concepts and Quantities.
Non-monochromatic and Random Radiation. Spectral Composition of Functions. Natural Linewidth of Radiation. Wave Packets. Quasi-plane wave. Coherence.
Propagation of Light in Dielectrics. Fresnel's Formulas. Total Reflection of Light. Reflection of Light from a Conducting Surface.
Geometrical Optics Approximation, Eikonal equation. Lenses, Mirrors and Optical Systems, Matrix notation. Optical Image. Optical Aberration. Optical Instruments.
Two-beam Interference Caused by Amplitude Division. Visibility for Gaussian and Lorentz line. White light interference pattern. Michelson interferometer. Mach-Zehnder, Twyman-Green interferometer. Jamin refractometer.
Two-beam Interference Through wavefront splitting. Finite-sized source. Coherence angle and coherence width. Stellar interferometer.
Multiple-beam Interference Through Amplitude Division. Interference in Thin Films.
Diffraction. Fresnel zone method. Kirchhoff's approximation. Fraunhofer Diffraction. Fresnel Diffraction.
Propagation of Light in Anisotropic Media. Birefringence. Polarization in birefringence. Polaroid. Pleochroism. Quarter-wave plate. Half-wave plate.
Rayleigh and Mie Scattering.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	45	Midterm exams	40
Assignments	10	Seminar	20
Total	100	Final exam	40
		Total	100

Literature

1. N. Matveev, *Optika*, Mir Publisher, Moscow 1988.
2. Corresponding material from the web-site "e-nastava" and notes from the lectures

Additional readings:

1. E. Hecht, *Optics*, Addison-Wesley, San Francisco 2002.
2. M. Born, E. Wolf, *Principles of optics*, 7th edition, Pergamon, Oxford 1999.

Remarks

A student must win a minimum of 22 points on partial exams in order to enter the final exam. To successfully pass, at the final exam the students must score at least 22 points, and the total score must be at least 55 points.