UNIVERSITY OF SARAJEVO

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

CURRICULUM FOR THE ACADEMIC YEAR 2018/2019

PHYSICS

SECOND CYCLE

GENERAL INFORMATION ABOUT THE STUDY PROGRAM

NAME OF THE STUDY PROGRAM:	Physics
TYPE OF THE STUDY PROGRAM:	University Study Program
LEVEL OF THE STUDY PROGRAM:	Second Cycle of Higher Education
GOALS OF THE STUDY PROGRAM:	• To gain fundamental knowledge and develop research skills in the field of physics research, • To improve knowledge and develop additional competences in the field of experimental physics or educational physics or theoretical physics or medical-radiological physics, physics of ionizing radiation and radiation protection, depending on the courses selected during the study (see the attached list of exams passed), • To develop competences and skills relevant to performing experiments and using mathematical formalism and computers in physics, • To develop understanding of scientific concepts and to be able to independently gain new knowledge, • To develop skills for participation in scientific projects, • To develop communicational, social, mathematical-informatics research skills.
PROVIDER OF THE STUDY PROGRAM:	University of Sarajevo, Faculty of Science, Department of Physics
SCIENTIFIC AREA OF THE STUDY PROGRAM:	Physics
STRUCTURE OF THE STUDY PROGRAM:	The classes are delivered in the form of lectures, seminars, recitations, labs/practices. In the first semester students choose between four categories of elective courses (experimental physics, theoretical physics, medical-radiological physics, educational physics). A total of 30 ECTS credits are allocated to elective courses and 24 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/English if needed
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“. 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 Level of the Qualification: Second cycle of higher education; Level 7 in Basis of Qualifications Framework in Bosnia and Herzegovina

PROFESSIONAL STATUS:	Depending on the selected courses (focus on experimental or theoretical or medical-radiological physics or educational physics) a master of science in physics degree qualifies the holder to work as a master of physics in various research laboratories, applied physics laboratories, research institutes, educational institutions, agencies devoted to measurements, standardization, environment protection and radiation protection, companies as well as in other institutions that employ masters of science in physics.
ACCESS TO FURHER STUDY:	The holder of the Master of Science in Physics 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 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:	**Competences related to physics and physics research** The diploma holders, depending on the selected courses (focus on experimental or theoretical or medical-radiological physics or educational physics – see the attached list of exams passed), are able to: • Explain fundamental principles of modern physics and solve advanced problems in the formalism of modern physics, • Plan and execute advanced experiments in physics, analyze experimental data and present their results, • Assess and quantify errors in measurements and procedures, • Use mathematics and computers for purposes of data acquisition and modeling of physical phenomena, • Successfully use software related to specific field of physics, • Select and use appropriate measuring equipment for scientific research, • Read scientific articles and discuss recent results in a specific field of physics, • Apply advanced methods, including the use of numerical methods and simulations to reproduce recent scientific results in a specific field of physics, • Evaluate critically and independently research methods and results in a specific field of physics.

	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 COMPULSORY AND ELECTIVE COURSES

PHYSICS II CICLE – 4 + 1

COURSES	CODES	SEMESTERS I L+E	SEMESTERS II L+E	ECTS POINTS
Data processing and modeling in physics	**PCM9611**	**3+2**		**6**
Elective course I				**6**
Elective course II				**6**
Elective course III				**6**
Elective course IV				**6**
Total hours/ECTS points				**30**
Elective course V				**6**
Master's thesis				**24**
Total hours/ECTS points				**30**

LIST OF POSSIBLE ELECTIVE COURSES

THEORETICAL PHYSICS

COURSES	CODES	ECTS POINTS
Quantum mechanics III	**PTH9611**	**6**
Symmetries in physics	**PTH9621**	**6**
Quantum field theory III	**PTH9631**	**6**
Photonics	**PTH0611**	**6**
Fourier optics	**PTH9651**	**6**
Elementary particle physics II	**PTH9661**	**6**
Gravitation and cosmology	**PTH9671**	**6**
Scattering theory	**PTH9681**	**6**
Interaction of electromagnetic field with atoms	**PTH9691**	**6**

EXPERIMENTAL PHYSICS

COURSES	CODES	ECTS POINTS
Solid state physics III	**PCM9611**	**6**
Interaction of Radiation with Solids	**PCM9651**	**6**
Semiconductor microdevices	**PCM9621**	**6**
Magnetic Materials	**PCM9631**	**6**
Defects in Solids	**PCM9641**	**6**
Physics of disordered systems	**PCM9681**	**6**
Nanomaterial physics	**PCM9691**	**6**
Fiber optics	**PAP9671**	**6**
Physics of Metals II	**PCM8611**	**6**
Physics of semiconductors II	**PCM8621**	**6**

MEDICAL RADIATION PHYSICS

COURSES	CODES	ECTS POINTS
Physics in diagnostic radiology	**PAP9611**	**6**
Physics in nuclear medicine	**PAP9621**	**6**
Physics in radiotherapy	**PAP9631**	**6**
Fundamentals of medicine for physicists	**PAP9641**	**6**
Simulation and data processing in medical radiation physics	**PAP9651**	**6**
Radiological imaging	**PAP9661**	**6**

PHYSICS EDUCATION

COURSES	CODES	ECTS POINTS
Physics teaching practice	**PED9011**	10
Physics education III	**PED9611**	6
Physics education laboratory III	**PED7411**	4
Physics education laboratory IV	**PED8421**	4
Physics education IV	**PED0611**	6

<table>
<tr><td>Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle</td></tr>
<tr><td></td><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">DATA PROCESSING AND MODELING IN PHYSICS</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>PCM9611</td><td>I</td><td>MANDATORY</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4"></td></tr>
<tr><td>Aims and expected learning outcomes</td><td colspan="4">The aim of the course is to teach the student to analyze and process physical data and numerically simulate physical processes.

After mastering the course, the student use suitable program packages for statistical data processing; student can choose a suitable statistical hypothesis and test it;</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">The concept of random variable. Discrete and continuous random variables and their moments. Special probability distributions: the binomial, geometric, Poisson,the normal, Lognormal, gammadistribution. Sampling theory: random sample, distribution of the mean of the sample. Standard deviation (error) of the mean of the sample. Point estimation. Interval estimation for the mean and variances. Test of statistical hypotheses. Theoretical distribution and empirical data. Correlation and regression analysis. ANOVA.</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>75</td><td>Midterm exams</td><td>50</td></tr>
<tr><td>Total</td><td>150</td><td>Final exam</td><td>50</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. Ratomir Paunović i Radovan Omorjan, Osnove inžinjerske statistike, Univerzitet u Novom Sadu, electronic edition</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4">The student must win a minimum of 55% of points on both midterm exam and final exam in order to successfully pass the exam.</td></tr>
</table>

LIST OF POSSIBLE ELECTIVE COURSES

THEORETICAL PHYSICS

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**QUANTUM MECHANICS III**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH9611	**I**	**ELECTIVE**	**6**	**3+2**

Lecturer	**Prof. dr. Dejan Milošević**
Aims and intended learning outcomes	The aim of the course is that students learn quantum mechanics at a higher level than in the introductory course. The knowledge of quantum mechanics is deepened through various examples and applications. The learning outcome is mastering the formalism of quantum mechanics and its applications in various areas of modern physics.

Course content

Formalism of quantum mechanics: Axioms of quantum mechanics. Unitary transformations. Time evolution of the system. Representations of quantum mechanics. Path integrals. Symmetry principles and conservation laws. Discrete transformations. Galilean transformation.
Angular momentum: Angular momentum and rotation. The addition of the angular momenta. Clebsch-Gordan's coefficients.
Approximative methods for time-dependent problems in quantum mechanics: Time-dependent perturbation theory. Adiabatic approximation. Berry phase. "Sudden" approximation.
Quantum mechanics of many particle systems: Identical particles. Bosons and fermions. Pauli's principle. Multielectron atoms. Molecules. Examples.
Interaction of quantum systems with an electromagnetic field: A charged particle in an electromagnetic field. Dipole approximation. Photoionization. Interaction with magnetic field. Aharonov-Bohm effect. Rabbi's experiment.
Quantum collision theory: Scattering cross-section. Scattering amplitude. Born approximation. Method of partial waves. Green's method. General properties of the T-matrix. Collisions of identical particles. Collisions of complex particles. Inelastic collisions.

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

Literature

Mandatory:
D. Milošević, Kvantna mehanika I and Kvantna mehanika II, 2015. (available at e-learning)
Lecture notes
L. I. Šif, Kvantna mehanika, Vuk Karadžić, Beograd, 1968.
Recommended:
B. H. Bransden, C. J. Joachain, Quantum mechanics, Prentice Hall, Harlow, 2000.
A. Messiah, Quantum mechanics, North-Holland, Amsterdam, 1968.
C. Cohen-Tannoudji, B. Diu, F. Laloe, Quantum mechanics, Wiley, New York, 1977.

Remarks

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**SYMMETRIES IN PHYSICS**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH9621	**I**	**ELECTIVE**	**6**	**3+1**

Lecturer	**Prof. dr. Aner Čerkić**
Aims and intended learning outcomes	Aim of the course is to introduce students into methods of the group theory and group representations, and into their applications to the description and analysis of the physical symmetries. Expected outcomes: Adopting the basic ideas in the continuous (Lie) group theory. Getting acquainted with continuous (Lie) group symmetries and with their applications in physics. Mastering the mathematical apparatus and methods applied in the analysis of properties of continuous groups.

Course content

Lie algebra. Adjoint representation. Direct product. Complex conjugate representation. Group SU(2). Group SU(3). Construction of weight diagrams. Tensors. Young tableaux. Lorentz transformations.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	50		
Assignments	30		
Other	10	Midterm exam	50
Total	150	Final exam	50
		Total	100

Literature

Mandatory literature:
1. I. Doršner, *Simetrije u fizici*, Prirodno-matematički fakultet Sarajevo, Sarajevo, 2013.

Additional literature:
1. H. F. Jones, Groups, *Representations and Physics*, 2nd edition, Taylor & Francis, 1998.
2. J. F. Cornwell, *Group Theory in Physics*, *An Introduction*, Academic Press, 1997.
3. W. Greiner, B. Müller, *Quantum Mechanics*: *Symmetries*, 2nd edition, Springer-Verlag 2004.
4. M. Hamermesh, *Group Theory and Its Application to Physical Problems*, Dover Publications, 1989.

Remarks

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**QUANTUM FIELD THEORY III**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH9631	**II**	**ELECTIVE**	**6**	**3+2**

Lecturer	**Prof. dr. Dejan Milošević**
Aims and intended learning outcomes	The aim of the course is to deepen students' knowledge of quantum field theory at a higher level than in the introductory course. The formalism of quantum field theory is applied to various areas of contemporary quantum theory. The learning outcome is mastering the formalism of quantum field theory and applications in various areas of modern physics.

Course content

Lorentz and Poincaré symmetries in quantum field theory. Classical field theory. Theorem Noether. Scalar fields. $U(1)$ charge. Spinor fields. Weyl equation. Dirac equation. Chiral symmetry. Majorana mass. Electromagnetic field. Quantization of free fields. Scalar fields. Fields with spin 1/2. CPT symmetries. Electromagnetic field. S-matrix. LSZ reduction formula. Wick's theorem and Feynman diagrams. Renormalization. Cross sections and decay rates. Quantum electrodynamics. Divergence. Electroweak interaction. Four-fermion model. The charged and neutral currents in the standard model. Path integral method in field theory. Scalar fields. Perturbations. Euclidean formulation of the path integral method. Critical phenomena. Quantum field theory at the finite temperature. Instantones. Non-abelian gauge theories. Yang-Mills theory. Quantum chromodynamics. Spontaneous symmetry breaking.

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

Literature

Mandatory:
1. D. Milošević, Relativistička kvantna mehanika, Univerzitetski udžbenik, bosnia ARS, Tuzla, 2005.
2. Lecture notes.

Recommended:
1. M. Maggiore, A modern introduction to quantum field theory, Oxford Master Series in Statistical, Computational, and Theoretical Physics, Oxford University Press, New York, 2005.
2. W. Greiner, J. Reinhardt, Field quantization, Springer, Berlin, 1996.

Remarks

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**PHOTONICS**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH0611	**I**	**ELECTIVE**	**6**	**3+3**

Lecturer	**Prof. dr. Senad Odžak**
Aims and intended learning outcomes	The aim of the course is to introduce students through lectures and auditorials on a more advanced level with phenomena in the field of Photonics. It is expected that students successfully adopt the content of the course and that the acquired knowledge is successfully applied in their further academic education and/or scientific work.

Course content

Ray optics. Wave optics. Beam optics. Fourier optics. Electromagnetic optics. Polarization optics. Photonic-crystal optics. Guided-wave optics. Fiber optics. Resonator optics. Statistical optics. Photon optics. Photons and atoms. Laser amplifiers. Lasers. Photons in semiconductors. Semiconductor photon sources. Semiconductor photon detectors. Acousto-optics. Electro-optics. Nonlinear optics. Ultra-fast optics. Optical interconnects and switches. Optical fiber communications.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	50	Course Test	40
Assignments	20	Assignment	20
Other	5	Final Exam	40
Total	150		
		Total	100

Literature

1. Lecture Notes
2. B. E. A. Saleh, M. C. Teich, Fundamentals of photonics, John Wiley & Sons, New York, 1991.
3. F. Graham, T. A. King, Optics and photonics, John Wiley & Sons, Chichester, 2000.
4. R. Menzel, Photonics, Springer, Berlin, 2001.

Remarks

The partial and final exam consists of a theoretical part and multiple assignments. The successful completion of the course implies achieving at least 55% of the total numer of points in course test, assignment and final exam. All examination is done by using the written method.

Program	Level of studies		**Second cycle**	
	Program name		**Physics**	
Course name	**FOURIER OPTICS**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH9651	**I**	**ELECTIVE**	**6**	**2+2**
Lecturer	**Prof. dr. Azra Gazibegović - Busuladžić**			
Aims and intended learning outcomes	The aim of the course is to familiarize students with Fourier optics, its application and some specific problems. A student who master the course applies a two-dimensional discrete fourier transform to solve problems in optics ; understands the resolution of problems associated with diffraction and propagation of light; knows the methods of optical system analysis.			

Course content

Anaysis of two-dimensional signals and systems. Local spatial frequencies. The discrete Fourier transform.
Foundations of scalar diffraction theory. The Kirchhoff forrmulation of diffraction by planar screen. The Reyleigh forrmulation of diffraction. Fresnel and Fraunhofer diffraction. Beam optics (Hermite-Gauss beams, Laguerre-Gauss beams, Bessel beams).
Computationam diffraction and propagation. The convolution approach. The Fresnel Transfer function approach.
Wave-optics analysis of coherent optical systems. Frequency analysis of optical imaging system. Confocal microscopy.
Wavefront modulation.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	90	Midterm exams	60
Total	150	Final exam	40
		Total	100

Literature

J. W. Goodman, *Introduction to Fourier optics*, third revised edition, W.H.Freeman & Co Ltd, 2004.
Additional reading:
G. Brooker, *Modern classical optics*, Oxford Master Series in Atomic, Optical and Laser Physics, Oxford University Press, Oxford, 2003

Remarks

The student must win a minimum of 55% of points on partial exams in order to enter the final exam

Study programme	Level of studies	**Second cycle**
	Module	**Physics**
Course title	**ELEMENTARY PARTICLE PHYSICS II**	

Code	Semestar	Status	ECTS	L+E
PTH9661	**I**	**ELECTIVE**	**6**	**2+1**

Lecturer	**Doc. dr. Admir Greljo**
Aims and intended learning outcomes	The goal of the course is to introduce advanced methods in elementary particle physics. The expected outcome is to enable students to perform scientific research in this area of physics.

Course contents

Review of the Standard Model of particle physics. Collider physics phenomenology. Monte Carlo methods in collider physics. Statistics for particle physics. Higgs boson production and decay processes at hadron colliders.

Working hours (h)		Exams and marks	
P + V	45	Type	Points
Exams	45	Midterm exam	35
Written	30	Final exam	35
Other		Homeworks	30
Total	120		
		Total	100

Literature

Main:

1. Introductory Lectures on Collider Physics / Tim Tait
2. Practical Statistics for the LHC / Cranmer
3. TASI 2013 lectures on Higgs physics within and beyond the Standard Model / Logan

Extended :

1. Fizika elementarnih čestica / Ivica Picek
2. Simetrije u fizici / Ilja Doršner
3. An introduction to quantum field theory / Michael E. [Edward] Peskin, Daniel V. Schroeder
4. Lie algebras in particle physics / Howard Georgi
5. A Modern Introduction to Quantum Field Theory / Maggiore
6. The Standard Model of Electroweak Interactions / Pich

Other

Study programme	Level of studies		**Second cycle**	
	Module		**Physics**	
Course title	**GRAVITATION AND COSMOLOGY**			
Code	Semestar	Status	ECTS	L+E
PTH9671	**I**	**ELECTIVE**	**6**	**2+1**
Lecturer	**Doc. dr. Admir Greljo**			
Aims and intended learning outcomes	The goal of the course is to introduce the main topic and methods in gravitation and cosmology. The expected outcome is to enable students to explore advanced topics as well as follow modern trends in this area of physics.			

Course contents

The general theory of relativity. Robertson-Walker metric. Einstein equations. Friedmann equations. The standard model of Cosmology. Thermal history of the Universe. Dark matter. Cosmic microwave background. Structure formation.

Working hours (h)		Exams and marks	
P + V	45	Type	Points
Exams	60	Midterm exam	35
Written	45	Final exam	35
Other		Homeworks	30
Total	150		
		Total	100

Literature

Main:
1. A No-Nonsense Introduction to General Relativity / Carroll
2. Cosmology / Baumann
3. Lectures on Dark Matter Physics / Lisanti

Extended :
1. Physical foundations of cosmology / Mukhanov
2. Spacetime and Geometry / Carroll
3. Gravitation and Cosmology / Weinberg

Other

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">SCATTERING THEORY</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>PTH9681</td><td>I</td><td>ELECTIVE</td><td>6</td><td>3+1</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Aner Čerkić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">Aim of the course is to introduce students into non-relativistic quantum scattering theory. Expected outcomes: Adopting the basic ideas and concepts of the quantum scattering theory. Mastering the mathematical apparatus of the quantum scattering theory. Getting acquainted with the applications of the quantum scattering theory</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Description of collision processes
Basic definitions. Kinematics.
Potential scattering
Potential scattering: General features. The method of partial waves. The integral equation of potential scattering. The Coulomb potential. The scattering of identical particles. The Born series. Semi-classical approximations. Variational methods. Time-dependent potential scattering.
General scattering theory
Quantum dynamics. The collision matrix. Transition probabilities and cross-sections. The determination of the collision matrix. Two-potential scattering.
Applications
Two-body collisions. Three-body collisions. The optical potential.</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>60</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>50</td><td></td><td></td></tr>
<tr><td>Assignments</td><td>30</td><td></td><td></td></tr>
<tr><td>Other</td><td>10</td><td>Midterm exam</td><td>50</td></tr>
<tr><td>Total</td><td>150</td><td>Final exam</td><td>50</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">Mandatory literature:
1. C. J. Joachain, Quantum collision theory, North-Holland, Amsterdam, 1975.
Additional literature:
1. S. Sunakawa, Kvantovaja teorija rassejanija, Mir, Moskva, 1979.
2. Dževad Belkić, Principles of quantum scattering theory, Institut of Physics Publishing, Bristol, 2004.
3. J. R. Taylor, Scattering theory: The quantum theory of nonrelativistic collisions, John Wiley & Sons, New York, 1972.
4. L. D. Landau, E. M. Lifšic, Teoretičeskaja fizika. Tom III: Kvantovaja mehanika. Nereljativistkaja teorija, Nauka, Moskva, 1989.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
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<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">INTERACTION OF ELECTROMAGNETIC FIELD WITH ATOMS</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>PTH9691</td><td>II</td><td>ELECTIVE</td><td>6</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Elvedin Hasović</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The goal of the course is to familiarize students with application of quantum mechanics and atomic physics in order to describe the interaction of electromagnetic fields with atoms.

At the end of the course the student should be able to:
-apply knowledge from quantum mechanics and atomic physics to describe various processes in the interaction of the electromagnetic field and atoms;
- Solve numerical problems in the field of interaction of electromagnetic radiation and atoms;</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Introduction. Basic concepts related to the interaction of the electromagnetic field and atoms. Classic description of the laser field. The dynamics of the electron in the laser field. Gauge transformation. Time-dependent perturbation theory. Multiphoton ionization. Above-threshold ionization. High-harmonics generation. Electron-atom scattering in a laser field.</td></tr>
</table>

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. C. J. Joachain, N. J. Kylstra, R. M. Potvliege, *Atoms in intense laser fields*, Cambridge University Press, 2012.
3. M. H. Mittleman, *Introduction to the theory of laser-atom interaction*, 2^{nd} ed, Plenum, New York, 1993.

Remarks

LIST OF POSSIBLE ELECTIVE COURSES

EXPERIMENTAl PHYSICS

Program	Level of studies		**Second cycle**	
	Program name		**Physics**	
Course name	**SOLID STATE PHYSICS III**			
Course ID	Semester	Course status	ECTS	L+E
PCM9611	**I**	**ELECTIVE**	**6**	**2+1**
Lecturer				
Aims and intended learning outcomes	Aim of the course is to deepen the students' knowledge in solid state physics to achieve an understanding of specific topics in microelectronics and nanotechnology. After the completion of the course students will be expected to have mastered the conceptual and mathematical tools necessary for the understanding and analysis of recent researches in solid state physics.			

Course content
Fermi surface. Experimental determination of Fermi surfaces: anomalous skin effect, cyclotron resonance, de Haas-van Alphen effect. Semiconducting devices. Diffusion current. Direct and indirect excitation. Dielectric properties. Clausius-Mossotti relation. Electron and ionic polarizability. Optical properties. Refraction, absorption, reflection. Kramers-Kronig relations. Intrazonal transitions. Magnetic properties. Adiabatic demagnetization. Electron paramagnetic resonance. Heisenberg's theory of ferromagnetism. Superconducting properties. London equations. Pippard's theory. Microscopic theory of superconductivity. Superconducting tunnelling.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	40	Homework	10
Assignments	25	Midterm exam	50
Consultation	40	Final exam	40
Total	150	Total	100

Literature
1. Ch. Kittel: Uvod u fiziku čvrstog stanja, Savremena administracija, Beograd, 1970. 2. H.M.Rosenberg: The Solid State, , Oxford Sci. Publ. 1988 3. H.C.Gupta: Solid State Physics, Vikas Publ, 1996.

Remarks
Midterm exam – 9th week of lectures

Program	Level of studies		**Second cycle**	
	Program name		**Physics**	
Course name	**INTERACTION OF RADIATION WITH SOLIDS**			
Course ID	Semester	Course status	ECTS credits	L+E
PCM9651	**I**	**ELECTIVE**	**6**	**2+1**
Lecturer	**Doc.dr. Maja Đekić**			
Aims and intended learning outcomes	Course objective is to familiarize students with interactions of different types of radiation (ionic and electron beams) with solids. Learning outcomes: 1. Knows and understands interaction of ionic beams with solids 2. Understands interaction of electron beams with solids 3. Knows how to apply this knowledge to independently solve problems from this field			

Course content

Interaction of ionic radiation with solids. Loss of energy and stopping power. Scattering on metallic surface. Neutralization of ions on metallic surface (possible emission of secondary electrons). Modification of materials with ionic beams. Technologies of ionic implantation. Interaction of electrons with solids. Interaction of photons with solids.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	50	Test	40
Assignments	45	Paper	40
Other	10	Final Exam	20
Total	150		
		Total	100

Literature

1. M. Nastasi, J.W. Mayer and J.K. Hirvonen Ion-Solid Interactions Cambridge U. Press 1996
2. H. Nikjoo, S.Uehara, D. Emfietzoglou: Interaction of radiation with matter, Taylor ¸Frqansis group, Boca Raton, 2012
3. Ed.: J.W. Rabalais. Low Energy Ion-Solid Interactions Wiley Interscience 1994
4. D.P. Woodruff and T.A. Delchar Modern Techniques of Surface Science, Second Edition Cambridge U. Press 1994

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**SEMICONDUCTOR MICRODEVICES**	

Course ID	Semester	Course status	ECTS credits	L+E
PCM9621	**I**	**ELECTIVE**	**6**	**2+0**

Lecturer	**Doc. Dr. Maja Đekić**
Aims and intended learning outcomes	Course objective is to familiarize students with basic properties of semiconductor micro devices, their production and operating principles. Learning outcomes: 1. Understands phenomena in semiconductor micro devices 2. Understands the methods for production of semiconductor micro devices 3. Is familiar with application of these devices

Course content

INTRODUCTION. Course content and objective: significance of semiconductor micro devices in modern world. P-n junction. Structure and operating principle. Electrical properties of p-n diode. Temperature dependence-volume and contact resistance. Metal-semiconductor junction-structure and operating principle. Schottky diode. Diode performances with small signals, high speed and frequency. Bipolar transistor-structure and operating principal. Unipolar filed effect transistor. JFET. MESFET. Optoelectronic devices. Photodiodes, Photo conductors, photo detectors. Solar cells. Light emitting diodes. Laser diodes.

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	50	Laboratory exercises	40
Assignments	50	Paper	40
Other	20	Final Exam	20
Total	150		
		Total	100

Literature

1. R. A. Smith, Semiconductors, Cambridge University Press, 1978.
2. S. M. Sze, Physics of Semiconductor Devices, 3rd ed., John Wiley & Sons, 2002

Remarks

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**MAGNETIC MATERIALS**	

Course ID	Semester	Course status	ECTS	L+E
PCM9631	**II**	**ELECTIVE**	**6**	**2+0**

Lecturer	
Aims and intended learning outcomes	Aim of the course is familiarising students with a quantum-mechanical explanation of magnetic phenomena, to enable them to follow recent researches on new magnetic phenomena and materials. After the completion of the course students will be expected to solve problems corresponding to the theoretical lectures and understand scientific papers regarding the newest magnetic materials and their applications.

Course content

Interaction between two moving charges. Coulomb interaction. Vector model of a magnetic atom. Magnetic susceptibility. Hamiltonian of an electron in a magnetic field. Susceptibility of inner-shell electrons. Paramagnetism of inner-shell electrons. Diamagnetism of inner-shell electrons. Van Vleck paramagnetism. Valence electrons susceptibility. Valence electron paramagnetism due to spin. Valence electron magnetism due to orbital motion. Ferromagnetism. Ferromagnetic domains in a crystal. Brillouin function. Heisenberg Hamiltonian of exchange interaction. Antiferromagnetism. Energy absorption. Bloch equations. Spin system in a linearly polarized radio-frequency field. Complex magnetic susceptibility. Dispersion. Theoretical basics of dispersion. Effect of other molecules in a medium on dispersion. Quantum theory of dispersion. General magnetic susceptibility. Kramers-Krönig relations. Fluctuation-dissipation theorem. Spin waves. Quantization of spin waves. Examples of magnetic systems.

Student workload (hours)		Grading	
Lectures	30	Assessment method	Points
Exam preparation	45	Homework	10
Assignments	45	Midterm exam	30
Consultation	30	Seminar paper	20
		Final exam	40
Total	150	Total	100

Literature

1. S. Bikić:Uvod u teoriju magnetizma, univerzitetski udžbenik, Fakultet za metalurgiju i materijale, Zenica, 2005
2. Mathias Getzlaff: Fundamentals of magnetism, Springer, 2008.

Remarks

Midterm exam – 8th week of lectures

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**DEFECTS IN SOLIDS**	

Course ID	Semester	Course status	ECTS credits	L+E
	I	**ELECTIVE**	**6**	**2+0**

Lecturer	**Doc.dr. Maja Đekić**
Aims and intended learning outcomes	Course objective is to familiarize students with defects in solids. Learning outcomes: 1. Is familiar with different defects in solids 2. Is familiar with formation of defects in solids 3. Is familiar with the influence of defects on the properties of materials.

Course content
Classification of defects. Lattice distortion and relaxation. Effective mass theory. Simple theory of deep levels in semiconductors. Vibrational properties and entropy. Thermodynamics of defects. Defect migration and diffusion.

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	50	Test	40
Assignments	50	Paper	40
Other	20	Final Exam	20
Total	150		
		Total	100

Literature
1. J. Bourgoin M. Lannoo, Point Defects in Semiconductors, Springer-Verlag, 1983. 2. J. Friedel, Dislocations, Addison-Wesley

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS OF DISORDERED SYSTEMS</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>PCM9681</td><td>I</td><td>ELECTIVE</td><td>6</td><td>2+1</td></tr>
<tr><td>Lecturer</td><td colspan="4"></td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of the course is to teach student the knowledge important for understanding and describing the disorder systems.
Expected learning outcomes: Understanding the terms order/disorder, fractals, and theories of percolation; self-use of literature and scientific papers in problem solving through seminar work; improving communication skills by presenting seminar work.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">• Introduction. Ordered and disordered systems. Order parameters.
• Fractals: fractal geometry, self-similarity, scale invariance, random fractals, DLA, fractal growth. Fractals and experiments.
• Percolation: geometrical phase transition, exact results (1D model, Bethe lattice), fractal geometry of percolation clusters, substructures.
• Examples of dissordered systems in physics: Glasses, Disordered magnets.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	60	Final exam	50
Seminar	45	Seminar	50
Total	150		
		Total	100

Literature

1. Lecture notes
2. N.E. Cusak, The Physics of Structurally Disordered Matter, Adam Higler, Bristol, 1988
3. A. Bunde, S.Havlin , Eds., Fractala and Disordered Systems, Springer, Berlin, 1996
4. D. Stauffer, A. Aharony, Introduction to Percolation Theory, Taylor& Francis, London, 1992
5. N. P. Kovalenko, Yu. P. Krasny, U. Krey, Physics of Amorphous Metals, Wiley-VCH,2001

Remarks

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">NANOMATERIAL PHYSICS</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>PCM9691</td><td>I</td><td>ELECTIVE</td><td>6</td><td>2+1</td></tr>
<tr><td>Lecturer</td><td colspan="4"></td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of the course is to introduce students with nanomaterials, open questions and research opportunities in this field.
Expected learning outcomes: Understanding the qualitative and quantitative properties of nanomaterials; self-use of literature and scientific papers in problem solving through seminar; Improving communication skills by presenting seminar.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">
• Introduction: a historical introduction to nanomaterials and technology development, unusual phenomena in nanomaterials.
• Nanostructure: fundamentals of crystal structure, the definition of nanomaterials, nanoparticles and clusters of atoms, different forms of nanomaterials, carbon nanostructures.
• Irregularities and diffusion: description of defects in a crystal, changing structural features from polycrystalline over microcrystalline to nanocrystalline materials, peculiarities in amorphous state, diffusion processes, differences in atomic diffusion from bulk materials to nanomaterials and amorphous materials.
• Metastable materials, from solid solution to nanostructures: phase diagrams, solid solutions and their structure, long-range and short-range order, superstructure, metastable structures and their preparation, relaxation of structures, occurrence of different nanostructures.
• Physical properties of materials: mechanical and similar: influence of defects on the mechanical properties, designing suitable mechanical properties (hardening and strengthening) of materials through their nanostructuring, special forms of applicable materials.
• Structural properties of special new materials: development of structural characteristics from bulk materials to nanomaterials, some special new materials: fullerene, graphene, nanotubes and nanowires, nanoporous materials.
• Transport phenomena in nanomaterials: electrical conductivity in nanomaterials, thermal conductivity of nanomaterials, thermoelectric effects, semiconductors.
• Magnetism of nanomaterials: occurrence and features of nanomagnets, magnetic behaviour of nanoparticles and their magnetic structures, single molecule nanomagnets, magnetism in metallic glasses, magnetic nanowires and thin films, nanocrystalline magnetic materials.
• Electronic structure and special properties of nanomaterials: density of states and low-dimensional conductivity, atomic microscopes, quantum dots and optical properties, electrical conductivity through the quantum dot.
</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	60	Final exam	50
Seminar	45	Seminar	50
Total	150		
		Total	100

Literature
1. Lecture notes 2. Skripta prof. Dr. Antun Tonejc: Fizika nanomaterijala, http://www.phy.pmf.unizg.hr/~atonejc/FMS%20PDS%20Studij.html 3. Charles Kittel, Introduction to solid state physics, poglavlje Nanostructures 4. Nicola Spladin, Magnetic Materials
Remarks

Program	Level of studies		**Second cycle**	
	Name of the program		**Physics**	
Name of the course	**FIBER OPTICS**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP9671	**I**	**ELECTIVE**	**6**	**2+1**
Lecturer	**Prof. dr. Edvin Skaljo**			
Aims and intended learning outcomes	The objective of the course is to get students acquainted with optical fibers and their application.			

Course content
Description of the process of light traveling through optical fiber: wave and geometric optics. Application of optical fibers in the transmission of information: at short and long distances. Glass fiber based sensors. Glass fiber based interferometers. Application of optical fibers in medicine and biology.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	50	Partial exam	40
Assignments	40	Practical work	20
Other	15	Student activity	10
Total	150	Final exam	30
		Total	100

Literature

1. D. Milatović: Optoelektronika, Svjetlost, Sarajevo 1989
2. Keiser, Gerd. *Optical fiber communications*. John Wiley & Sons, Inc., 2003.
3. Keiser, Gerd. *Biophotonics: Concepts to Applications*. Springer, 2016.

Remarks

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="2">First cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS OF METALS II</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS</td><td>L+E</td></tr>
<tr><td>PCM8611</td><td>VIII</td><td>ELECTIVE</td><td>6</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4"></td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">Aim of the course is introduction to phase, thermodynamic stability and phase transformations in metals and their alloys.
After the completion of the course, students will be expected to understand the basic principles of phase equilibrium which enable the construction and interpretation of phase diagrams, the solubility and evolution of equilibrium and non-equilibrium microstructures, the theory of diffusion processes, the thermodynamics and kinetics of phase transformations.</td></tr>
</table>

Course content

Equilibrium diagrams Types. Example 1: Equilibrium diagram of a binary system in which the components form a mixture of crystals in the solid state and are completely soluble in the liquid state. Example 2: Equilibrium diagrams for binary systems in which the components are completely soluble in the liquid state and partially soluble in the solid state. Example 3: Solid solutions with unlimited solubility. Binary alloys. Gibbs free energy as a function of temperature and concentration. Chemical potential and activity. Raoult's law. Ideal, regular and real solid solutions. Equilibrium concentration of vacancies. Example of forming an equilibrium diagram for a binary system by drawing the curves of free energy.
Equilibrium diagrams for multi-component systems. Diffusion in metals. Atomic mechanisms of diffusion. Interstitial diffusion. Substitutional diffusion. Self-diffusion. Vacancy diffusion. Diffusion in substitutional alloys. Kirkendall effect. Grain boundary diffusion and surface diffusion. Amorphous metals – metallic glasses. Production methods and structure (models) Relaxation processes in amorphous metals.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	40	Homework	10
Assignments	20	Seminar paper	10
Consultation	30	Midterm exam	40
Total	150	Final exam	40
		Total	100

Literature

1. T. Mihać: Fizika metala, nerecenzirana skripta
2. T. Mihać: Praktikum iz fizike metala, Univerzitetska knjiga, Sarajevo 2001.
3. Ch. Kittel: Uvod u fiziku čvrstog stanja, Savremena administracija, Beograd, 1970.
4. S. Tomašević, R. Zrilić, D. Ćubela: Nauka o materijalima, Apex, Zenica, 2000.
5. I. Vitez., M .Oruč., R .Sunulahpašić., Ispitivanje metalnih materijala: Mehanička i tehnološka ispitivanja, Fakultet za metalurgiju i materijale, Zenica, 2006.
6. D. A. Porter, K. E. Easterling: Phase transformations in metals and Alloys, Chapman&Hall 1984.

Remarks

Midterm exam – 9th week of lectures

Program	Level of studies	**First cycle**
	Program name	**Physics**
Course name	**PHYSICS OF SEMICONDUCTORS II**	

Course ID	Semester	Course status	ECTS	L+E
PCM8621	**VIII**	**ELECTIVE**	**6**	**2+2**

Lecturer	**Doc. dr. Maja Đekić**
Aims and intended learning outcomes	Course objective is to familiarize students with basic properties and processes in semiconductors. Learning outcomes: 1. Understands phenomena and laws in semiconductors 2. Independently solves problems from this field 3. Understands semiconductor applications

Course content

INTRODUCTION. Content of the course, significance of semiconductors. Diffusion and drift of carriers. Continuity equation: Diffusion equation. Einstein's relation. Diffusion and conductivity in extrinsic semiconductors. Nearly intrinsic semiconductors. Scattering of electrons and holes. Scattering processes. Scattering on lattice vibrations. Phonons. Relaxation time. Scattering on neutral and ionized impurities. Scattering on defects. Generation and recombination. Radiative recombination. Auger recombination. Recombination due to traps and localized centres. Surface recombination. Optical phenomena in semiconductors, optical constants. Absorption by free carriers, lattice, impurities, defects, exciton. Photo conductivity. Contact phenomena in semiconductors. Debye length. Work function. Contact voltage. Amorphous semiconductors and liquid crystals.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	50	Test	40
Assignments	40	Paper	40
Other		Final exam	20
Total	150		
		Total	100

Literature

1. R. A. Smith, Semiconductors, Cambridge University Press, 1978.
2. S. M. Sze, Physics of Semiconductor Devices, 3rd ed., John Wiley & Sons, 2002.

Remarks

LIST OF POSSIBLE ELECTIVE COURSES

MEDICAL RADIATION PHYSICS

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS IN DIAGNOSTIC RADIOLOGY</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>PAP9611</td><td>II</td><td>ELECTIVE</td><td>6</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. dr. Adnan Beganović</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">Aim: to provide students with detailed theoretical and practical knowledge of physics in modern diagnostic radiology and to prepare students for independent work as medical physicists.
Outcomes: master and understand the modern methods and techniques used in clinical diagnostic radiology and apply them in everyday medical practice</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">1. Physics in Diagnostic Radiology: Introduction; The Physical Basis of Diagnostic Radiology and Terminology; Exercises.
2. X-ray radiation devices in diagnostic radiology: Conventional X-ray tube; Source of electrons; Rectifiers; Structure of anodes and cathode; Diagnostic X-ray characteristics; X-radiation spectra; Interaction of anode electrons; Characteristic radiation; Bremsstrahlung; Angular distribution of x-rays; Large and small focus; Exercises.
3. Detectors in diagnostic radiology: X-ray film; Silver bromide; Exposure to x-radiation; Developing the film and effects in the film caused by the interaction with the developer; X-ray film features; Optical density; H-D curve; Intensifiers and Fluorescent Screens: Fluorescence Mechanism; Electronic traps; Luminescent materials; Grid; Screens; Screen thickness; Display production materials; Sharpness of the picture; Improper images; Fluoroscopic screens; Digital detectors; Computed Radiography and Direct Digital Radiography; Exercises.
4. Diagnostic radiology modalities: Radiography; Patient dosimetry in radiography; Skin entrance dose; Radiation output; Fluoroscopy; Patient dosimetry in fluoroscopy; Air KERMA–area product; Tomography; Computed tomography; Patient dosimetry in computed tomography; Computed tomography Air KERMA index; Mammography; Patient dosimetry in mammography; Mean glandular dose; Digital subtraction angiography; Ultrasound; Nuclear magnetic resonance; Spectroscopy in Magnetic Resonance; Exercises.
5; Image viewing devices: Monitors in diagnostic radiology; Lightboxes.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	80	Midterm	45
Other	10	Final	45
Total	150	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**
Course name	**PHYSICS IN NUCLEAR MEDICINE**	

Course ID	Semester	Course status	ECTS credits	L+E
PAP9621	**I**	**ELECTIVE**	**6**	**3+3**

Lecturer	**Prof. dr. Senad Odžak**
Aims and intended learning outcomes	The objective of the course is to give students theoretical and practical knowledge in physics in modern nuclear medicine as well as to prepare students for independent work as medical physicists. The specific objective of the course is to adopt modern methods and techniques used in clinical nuclear medicine. It is expected that students successfully adopt the content of the course and that the acquired knowledge is successfully applied in everyday medical practice.

Course content

Introduction. Radionuclides and their production. The Gamma camera. Image quality in Nuclear Medicine. Tomographic reconstruction in Nuclear Medicine. Single Photon Emission Computed Tomography (SPECT). Positron emission tomography (PET). Hybrid systems (SPECT/CT and PET/CT). Digital image processing in Nuclear Medicine. Tracer Kinetic Modeling. Internal Radiation Dosimetry. Radiation Safety in Nuclear Medicine.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	70	Course Test	50
Assignments	0	Final Exam	50
Other	5		
Total	150		
		Total	100

Literature

1. Lecture Notes
2. Cherry S.R., J.A. Sorenson, M.E. Phelps, Physics in Nuclear Medicine, Fourth Edition, Elsevier Science (USA), Philadelphia, Pennsylvania, 2012.
3. Hendee W. and E. R. Ritenour, Medical Imaging Physics, (Fourth Edition), John Wiley & Sons, Inc., New York, 2002.

Remarks

Examination requirement is successfully completing practical exercises at Clinical center University of Sarajevo (KCUS). The partial and final exam consists of a theoretical part and multiple assignments. The successful completion of the course implies achieving at least 55% of the total number of points in both the partial and final exam. All examination is done by using the written method.

Program	Level of studies	**Second cycle**
	Program name	**Physics**
Course name	**PHYSICS IN RADIOTHERAPY**	

Course ID	Semester	Course status	ECTS credits	L+E
PAP9631	**I**	**ELECTIVE**	**6**	**2+2**

Lecturer	**Prof. dr. Davorin Samek**
Aims and intended learning outcomes	Aim: to provide students with detailed theoretical and practical knowledge of physics in modern radiotherapy and to prepare students for independent work as medical physicists. Outcomes: master and understand the modern methods and techniques used in clinical radiotherapy and apply them in everyday medical practice

Course content

1. Introduction. Absorbed dose measurement: Absorbed dose; The relationship between KERMA, exposure and absorbed dose. Calculation of the absorbed dose from the exposure; Calibration protocol for megavoltage beams; Transfer of absorbed dose from one medium to another; Exercises
2. Dose distribution and scatter analysis: Phantoms; Dose depth distribution; Percentage depth dose and dependence on beam parameters; Dosimetry calculation systematics; Linear accelerator calculations (SSDs and isocentric techniques); Co-60 calculations; Irregular and asymmetric fields; Exercises
3. Treatment Planning. Isodose distribution; Isodose diagram; Measurement of the isodose curves; Parameters of isodose curves; Wedge filters; Beam quality influence; Combined radiation fields; Opposite fields; Three-Field Technique; Special fields; Techniques using wedges; Intensity Modulated Radiation Therapy (IMRT), Volumetric modulated arc radiotherapy (VMAT); Total body irradiation (TBI), Stereotactic body radiotherapy and radiosurgery (SBRT and SRS), Image Guided Radiotherapy (IGRT), Gamma-Knife, Simulation and verification of treatment; Exercises
4. Electron Therapy: Electron interactions; Energy loss; Electron scatter; Determination of absorbed dose; Radiation output calibration; Dose depth distribution; Characteristics of clinical electron beam; Treatment planning; Total irradiation of the skin; Large field technique; Exercises.
5. Basics of brachytherapy: Radioactive sources; Construction and protection of sources in brachytherapy; Dose limits and risks; Linear sources; Calibration of brachytherapy sources; Brachytherapy in gynaecology; Brachytherapy dosimetry; Special techniques; exercises
6. Quality Control in Radiotherapy: Planning the structure and number of employees; Equipment; Dosimetry accuracy; Acceptance tests; Periodic quality control; Exercises.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	80	Midterm	45
Other	10	Final	45
Total	150	Activity	10
		Total	100

Literature

1. Pdgoršak EB, editor. Review of Radiation Oncology Physics: A Handbook for Teachers and Students. Vienna, Austria: IAEA; 2005.
2. 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**	
Course name	**FUNDAMENTALS OF MEDICINE FOR PHYSICISTS**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP9641	**I**	**ELECTIVE**	**6**	**3+0**
Lecturer	**Prof. dr. Sandra Vegar - Zubović**			
Aims and intended learning outcomes	The aim of this course is to provide students with basic knowledge in anatomy, physiology and psychology, which would enable students to interact successfully with other medical personnel and patients, working as medical physicists. It is expected that students who master the course will master and understand the basics of anatomy and physiology; They master the psychology of communicating with patients, and understand the medical ethics.			

Course content
General structure and organization of the human body. Medical terminology Latin and Greek names for the most important organs, bones and tissues of the human body Fundamentals of anatomy of the human body. Basic physiology of human organs. Oncology. Identification of individual structures and organs in the body based on a medical image. Psychology of communication in medical institutions. Ethics in medical care. A vow of secrecy of data. General organization of the hospital.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	60	Midterm exams	30
Assignments	45	Seminar	20
Total	150	Final exam	50
		Total	100

Literature

1. Alpen E.L., Radiation Biophysics, (Second Edition), Academic Press, 1998
2. Burns D.M and S. McDonald, Fizika za biologe i medicinare, Školska knjiga, Zagreb, 1975
3. Gayton S., Medicinska fizologija, Medicinska knjiga Beograd-Zagreb, 1978

Remarks

Program	Level of studies		**Second cycle**	
	Program name		**Physics**	
Course name	**SIMULATION AND DATA PROCESSING IN MEDICAL RADIATION PHYSICS**			
Course ID	Semester	Course status	ECTS credits	L+E
PCS9621	**I**	**ELECTIVE**	**6**	**2+2**
Lecturer	**Doc. dr. Adis Alihodžić, Prof. dr. Davorin Samek**			
Aims and intended learning outcomes	The aim of the course is to teach the students to analyze and process physical data and medical images, and to learn appropriate sofware packages use. After mastering the course students can use MATLAB / Octave software packages for statistical processing data, process simulation and image processing.			

Course content

Stochastic and deterministic events. Graphical and numerical methods in statistics. Comparative studies. Measures of morbidity and mortality. Relative risk. Mantel-Heinsel method. Standardized Mortality Rate. Tools for statistics in MATLAB and Octave. Functions and apps to describe, analyze, and model data. Descriptive statistics. Generating random numbers for Monte Carlo simulations. Regression and classification algorithms. Correlation coefficient.
Multiple regression analysis. Regression model with several independent variables. Polynomial regression. Estimation and significance of regression parameters. Logistic regression.
Medical image processing, analysis and visualization. Image segmentation, noise reduction, geometric transformation.

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

Literature

1. Chap T. LE, Introductory Biostatistics, John Wiley & Sons, Inc., Hoboken, New Yersey, 2003
2. MathWorks, Statistics and Machine Learning Toolbox
3. MathWorks, Image Processing Toolbox

Remarks

The student must win a minimum of 55% of points on both midterm exam and final exam in order to successfully pass the exam.

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="2">Second cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">RADIOLOGICAL IMAGING</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>PAP9661</td><td>II</td><td>ELECTIVE</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. dr. Adnan Beganović</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">Objective: To give students detailed theoretical and practical knowledge of medical imaging in diagnostic radiology and nuclear medicine.
Outcomes: ovladati i razumjeti moderne metode i slikovnih tehnika u medicini.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">1. Introduction: The basic concept of imaging methods in radiology; Image quality; Spatial resolution, Convolution; Contrast; Noise; Contrast-to-noise ratio; Signal-to-noise ratio; IT systems; Digital radiological images; PACS and teleradiology; Image processing.
2. Imaging methods in diagnostic radiology: X-ray production; X-ray tubes; X-ray generators; Radiography; Geometry of projection radiography; Screen-film radiography; Computed radiography; CCD and CMOS detectors; FP detectors; Technique factors in radiography; Scintillators and intensifying screens; Exposure index; Dual-energy radiography; Scattered radiation in projection radiography; Mammography; Quality of x-rays in mammography; Compression, scattered radiation and magnification in mammography; Film and film processing; Digital mammography; Fluoroscopy; Detector systems in fluoroscopy; Image quality in fluoroscopy; Computed tomography; CT design; Image reconstruction; Image quality in CT; Magnetic resonance imaging; Ultrasound.
3. Imaging methods in nuclear medicine: Radioactivity; Production of radionuclides and radiopharmaceuticals; Radiation detection and measurement; Gas detectors; Scintillation detectors; Semiconductor detectors; Spectroscopy; Scintillation camera; Emission tomography; Single Photon Emission Tomography; Positron emission tomography; Hybrid systems.</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>65</td><td>Midterm</td><td>45</td></tr>
<tr><td>Other</td><td>10</td><td>Final</td><td>45</td></tr>
<tr><td>Total</td><td>150</td><td>Activity</td><td>10</td></tr>
<tr><td></td><td></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. 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. Bailey DL, Humm JL, Todd-Pokropek A, van Aswegen A, editors. Nuclear Medicine Physics: A Handbook for Teachers and Students. Vienna, Austria: IAEA; 2014.
3. Bushberg JT, Boone JM. The essential physics of medical imaging. Philadelphia: Lippincott Williams & Wilkins; 2011.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4">Exercises are performed at the Clinical Centre of Sarajevo University.</td></tr>
</table>

LIST OF POSSIBLE ELECTIVE COURSES
PHYSICS EDUCATION

<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</td></tr>
<tr><td>Course name</td><td colspan="4">Physics teaching practice</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>PED9011</td><td>I</td><td>ELECTIVE</td><td>10</td><td>4+4</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' skills of planning, conducting and analyzing physics lessons in faculty and school environment, as well as in deepening students' understanding of selected physics topics.
Intended learning outcomes:
1) Create a portfolio which documents development of skills related to planning and analysing physics lessons.
2) Conduct physics lessons in the faculty classroom and school environment.
3) Observes and analyses physics lessons and engages in self-reflection.
4) Identifies students' misconceptions and facilitates the process of conceptual change.
5) Demonstrates deep conceptual understanding of physics topics that are part of the physics curricula in Canton Sarajevo.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Role of teaching practice within initial physics teacher education. Developing a work plan for physics teaching practice. Portfolio: role, structure, process of learning.
Physics curriculum: actual physics curricula, core curricula and school curricula, differentiating curricula. Developing work plans in physics education. Physics textbooks and other educational media. Model of physics lesson plans. Guidelines for observing and evaluating physics lessons.
Developing a plan of teaching practice in the school environment.
Developing a plan of teaching practice in the faculty classroom environment.
Observing and simulating classes in the faculty classroom environment.
Analysing physics classes that had been conducted in the faculty classroom environment.
Observing and conducting classes in the authentic school environment.
Analysing physics classes that had been conducted in the school environment.
Reflection on teaching practice experiences and discussion about students' portfolios.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	120	Assessment method	Points
Exam preparation	80	Portfolio	15
Assignments	40	Partial exam	35
Other	10	Final exam	50
Total	250		
		Total	100

Literature

1. Muratović, H., Mešić, V. (2009). *Didaktičko-metodički prilozi nastavi fizike*. Sarajevo: Prirodno-matematički fakultet.
2. Physics textbooks for the primary and secondary school level.
3. Lemov, D. (2015). *Teach like a champion 2.0: 62 techniques that put students on the path to college*. John Wiley & Sons.

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</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>ELECTIVE</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 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>
</table>

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 rowspan="2">Study program</td><td>Level of the study program</td><td colspan="2">Second cycle</td></tr>
<tr><td>Name of the study program</td><td colspan="2">Physics</td></tr>
<tr><td>Course name</td><td colspan="4">LABORATORY IN 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>PED7411</td><td>I</td><td>ELECTIVE</td><td>4</td><td>0+3</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' knowledge, skills and habits that are important for effective implementation of the experimental method in physics classrooms.
Intended learning outcomes:
1. Systematically prepare physics experiments, including a written plan for implementation of the experimental method.
2. Conduct physics experiments and thereby take into account the potential safetey risks.
3. Analyse experimental data, identify sources of error and suggest potential ways of improving the experimental setup.
4. Present and discuss the experimental results by using multiple representations and taking into account of basic principles of cognitive psychology.
5. Identify, evaluate and design hands-on experiments in physics.
6. Solve experimenal exercises and laboratory problems.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Introducing the students with the syllabus.
Independence of perpendicular components of motion. Projectile motion.
Rotational motion.
Conservation laws in mechanics.
Fluid dynamics.
Basics of thermodynamics and molecular kinetic theory.
Mechanical oscillations and waves - part I.
Mechanical oscillations and waves - part II.
Direct current. Electric current in fluids.
Alternating current. Electromagnetic oscillations and waves.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	25	Partial exam	30
Assignments	25	Experimental exercises and laboratory problems	10
Other	5	Project	10
Total	100	Final exam	50
		Total	100

Literature

1. Mešić, V. (n.d.). *Praktikum metodike nastave fizike III* (interna skripta). Sarajevo: Prirodno-matematički fakultet.
2. Physics textbooks for primary and secondary school.
3. Sprott, J. C. (2006). *Physics Demonstrations: A sourcebook for teachers of physics*. University of Wisconsin Press.

Remarks

A passing grade on individual laboratory reports is a prerequisite for getting access to the final exam.

Study program	Level of the study program	**Second cycle**
	Name of the study program	**Physics**
Course name	**LABORATORY IN PHYSICS EDUCATION IV**	

Course ID	Semester	Course status	ECTS credits	L+E
PED8421	**I**	**ELECTIVE**	**4**	**0+3**

Lecturer	**Prof. dr. Vanes Mešić**

Aims and intended learning outcomes

The aim of this course is to develop students' knowledge, skills and habits that are important for effective implementation of the experimental method in physics classrooms with particular focus on use of modern technologies and experimental projects.

Intended learning outcomes:

1. Systematically prepare, conduct, evaluate and present physics experiments.
2. Perform digital video analysis of selected physics phenomena and demonstrate the ability to use microcomputer-based laboratories in the physics classroom.
3. Demonstrate virtual physics experiments and solve virtual laboratory problems.
4. Prepare, implement and present experimental projects in physics.

Course content

Introducing the students with the syllabus.
Double-slit interference.
Interference in thin films.
Optical grating.
Single slit diffraction.
Polarization.
Light scattering. Light absorption. Colors.
Virtual physics experiments.
Digital video analysis of selected physics phenomena.
Microcomputer-based laboratories.
Role of experimental projects in physics teaching.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	25	Partial exam	15
Assignments	25	Homework	10
Other	5	Experimental project	25
Total	100	Final exam	50
		Total	100

Literature

1. Mešić, V. (n.d.). *Praktikum metodike nastave fizike IV* (interna skripta). Sarajevo: Prirodno-matematički fakultet.
2. Physics textbooks for primary and secondary school.
3. Sokoloff, D. R., Thornton, R. K., & Laws, P. W. (2011). *RealTime Physics Active learning laboratories, Module 1: Mechanics*. John Wiley & Sons.
4. Eisenkraft, A. (2010). *Active physics: A project-based inquiry approach*. Armonk, NY: It's About Time.

Remarks

A passing grade on individual laboratory reports is a prerequisite for getting access to the final exam.

Study program	Level of the study program	**Second cycle**
	Name of the study program	**Physics**
Course name	**PHYSICS EDUCATION IV**	

Course ID	Semester	Course status	ECTS credits	L+E
PED0611	**II**	**ELECTIVE**	**6**	**3+2**

Lecturer	**Prof. dr. Vanes Mešić**
Aims and intended learning outcomes	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.

Course content

Learning and teaching about wave optics. Learning and teaching about ray optics. Learning and teaching about optical instruments. Learning and teaching about electric field 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.

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