UNIVERSITY OF SARAJEVO

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

CURRICULUM FOR THE ACADEMIC YEAR 2018/2019

PHYSICS

FIRST 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:	First Cycle of Higher Education
GOALS OF THE STUDY PROGRAM:	• To provide the student with knowledge and skills in the field of general physics, experimental physics, theoretical physics, medical-radiological physics, mathematical methods in physics and numerical modeling, • To develop understanding of physical concepts and abilities of solving general physics problems, • To gain basic knowledge in modern physics, • To develop competences and skills relevant to performing experiments and using mathematical formalism and computers in physics, • To develop communicational, social, mathematical and 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 three years of study students enroll in compulsory courses, as well as in three elective courses in the 1st, 3rd and 6th semester, respectively. In the fourth year of study students choose between four categories of elective courses (experimental physics, theoretical physics, medical-radiological physics, educational physics). A total of 26 ECTS credits are allocated to elective courses in the fourth year of study.
DURATION OF THE STUDY PROGRAM:	The study program lasts for 4 years (8 semesters).
LANGUAGE OF THE STUDY PROGRAM:	Bosnian/Croatian/Serbian
ENTRY ROUTES AND SELECTION CRITERIA:	All individuals who have completed upper secondary education (Level 4 in Basis of Qualifications Framework in Bosnia and Herzegovina) are eligible to apply for the 1st cycle study program „Physics“. Applicants are ranked according to their grade point average and academic performance in relevant courses (physics, mathematics, informatics, Bosnian/Croatian/Serbian language) at upper secondary school level, as well as according to other criteria set out in the public call for applications.
INFORMATION ABOUT THE QUALIFICATION:	Qualification Title: Bachelor of Science in Physics Level of the Qualification: First cycle of higher education; Level 6 in Basis of Qualifications Framework in

	Bosnia and Herzegovina
PROFESSIONAL STATUS:	The Bachelor of Science in Physics degree qualifies the holder to work as a bachelor of physics in research institutes, laboratories, higher education institutions, agencies, companies as well as in other institutions that employ bachelors of physics.
ACCESS TO FURHER STUDY:	The holder of the Bachelor of Science in Physics degree is eligible to apply for admission to second 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:	**Learning outcomes - Physics** The diploma holders are able to: ● Formulate and solve problems in general physics at the difficulty level of typical introductory courses of physics, ● Plan and execute experiments situated within the context of general physics, as well as to analyze experimental data and discuss the results, ● Formulate and solve problems of applied physics, introductory theoretical and experimental physics, ● Use mathematical formalism and computers for purposes of modeling simple physical phenomena. **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.
PRACTICAL WORK:	Practical work is implemented through practical courses and laboratory exercises.

Physics Laboratory I	4 ECTS
Physics Laboratory II	3 ECTS
Physics Laboratory III	4 ECTS
Physics Laboratory IV	2 ECTS
Physics Laboratory V	3 ECTS
Advanced General Physics Laboratory	4 ECTS
Physics Laboratory – Advanced Course I	3 ECTS
Physics Laboratory – Advanced Course II	3 ECTS
Electronics I	2 ECTS
Electronics II	2 ECTS

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 240 ECTS credits. Students are not required to prepare a final thesis.

LIST OF COMPULSORY AND ELECTIVE COURSES

FIRST AND SECOND YEAR

COURSES	SEMESTERS					
		I	II	III	IV	(E)CTS CREDITS
	CODE	L+E	P + V	L+E	P + V	
Mechanics	**PHY1711**	**3+3**				**7**
Physical Measurements I	**PHY1611**	**3+2**				**6**
Linear algebra for physicists	**POT1711**	**3+3**				**7**
Mathematical Analysis for physicists I	**POT1721**	**3+3**				**7**
Elective course						**3**
Total ECTS credits						**30**
Oscillations, waves and fundamentals of thermodynamics	**PHY2711**		**3+3**			**7**
Physical Measurements II	**PHY2511**		**2+1**			**5**
Mathematical Analysis for physicists II	**POT2811**		**3+4**			**8**
Physics laboratory I	**PHY2411**		**0+3**			**4**
General chemistry for physicists	**POT2411**		**2+1**			**4**
Elective course						**2**
Total ECTS credits						**30**
Electromagnetism	**PHY3611**			**3+2**		**6**
Classical mechanics I	**PTH3711**			**3+3**		**7**
Mathematical methods of physics I	**PCS3011**			**4+4**		**10**
Physics Laboratory II	**PHY3311**			**0+2**		**3**
Physics Laboratory III	**PHY3411**			**0+3**		**4**
Total ECTS credits						**30**
Optics	**PHY4611**				**3+2**	**6**
Introduction to atomic physics	**PHY4511**				**2+2**	**5**
Classical mechanics II	**PTH4711**				**3+3**	**7**
Mathematical methods of physics II	**PCS4011**				**4+4**	**10**
Physics Laboratory IV	**PHY4211**				**0+2**	**2**
TOTAL ECTS						**30**

L-lectures, E-excercises

THIRD AND FOURTH YEAR

COURSES		SEMESTERS				
		V	VI	VII	VIII	(E)CTS CREDITS
	CODE	L+E	P + V	L+E	P + V	
Quantum mechanics I	**PTH5711**	**3+2**				**7**
Theory of Electromagnetic Field	**PTH5611**	**2+2**				**6**
Solid state physics I	**PCM5611**	**2+2**				**6**
Introductory nuclear physics	**PHY5411**	**2+1**				**4**
Physics Laboratory V	**PHY5311**	**0+2**				**3**
Advanced General Physics laboratory	**PHY5421**	**0+3**				**4**
Total ECTS credits						**30**
Quantum mechanics II	**PTH6711**		**3+2**			**7**
Statistical physics	**PTH6611**		**3+2**			**6**
Special theory of relativity	**PTH6511**		**2+2**			**5**
Solid state physics II	**PCM6511**		**2+2**			**5**
History of physics	**PHY6311**		**2+0**			**3**
Elective course			**2+1**			**4**
Total ECTS credits						**30**
Computational Physics I	**PCS7611**			**2+2**		**6**
Electronics I	**PAP7511**			**2+2**		**5**
Experimental methods in modern physics	**PCM7211**			**2+0**		**2**
Advanced Physics Laboratory I	**PCM7311**			**0+3**		**3**
Elective courses						**14**
Total ECTS credits						**30**
Computational Physics II	**PCS8611**				**2+2**	**6**
Electronics II	**PAP8611**				**2+2**	**6**
Development of modern theoretical physics	**PTH8311**				**2+0**	**3**
Advanced Physics Laboratory II	**PCM8311**				**0+3**	**3**
Elective courses						**12**
Total ECTS credits						**30**

LIST OF POSSIBLE ELECTIVE COURSES IN FIRST YEAR

Elective course/semester		I L+E	II L+E	(E)CTS CREDITS
	CODE			
Introduction to computer science for physicists I	**PCS1311**	0+3		3
Communication Skills for Physicists	**PED1311**	2+1		3
Introduction to computer science for physicists II	**PCS2211**		0+2	2
English language	**POT221 1**		2+0	2
With the appropriate decision of the Council of Physics Department, every academic year, a list of possible elective subjects can be added to some of the subjects that are part of the adopted curricula at the University of Sarajevo.				

LIST OF POSSIBLE ELECTIVE COURSES IN VI, VII I VIII SEMESTER

THEORETICAL PHYSICS

Elective course \Semester	CODE	VI L+E	VII L+E	VIII L+E	(E)CTS CREDITS
Laser physics fundamentals	**PTH6411**	2+1			4
Fundamentals of chaos theory	**PTH6421**	2+1			4
Advanced course of optics	**PTH6431**	2+1			4
Electrical measurements of non-electric quantities	**PCM6411**	2+1			4
Atomic and molecular physics	**PTH7511**		3+1		5
Quantum field theory I	**PTH7521**		2+2		5
Mathematical methods of physics III	**PTH7411**		2+1		4
Quantum field theory II	**PTH8611**			2+2	6
Elementary particle physics I	**PTH8621**			2+2	6

EXPERIMENTAL PHYSICS

Elective course \Semester	CODE	VI L+E	VII L+E	VIII L+E	(E)CTS CREDITS
Laser physics fundamentals	**PTH6411**	2+1			4
Fundamentals of chaos theory	**PTH6421**	2+1			4
Advanced course of optics	**PTH6431**	2+1			4
Electrical measurements of non-electric quantities	**PCM6411**	2+1			4
Physics of Metals I	**PCM7511**		2+2		5
Physics of semiconductors I	**PCM7521**		2+1		5
Physics of Thin Films	**PCM7411**		2+0		4
Physics of Metals II	**PCM8611**			2+2	6
Physics of semiconductors II	**PCM8621**			2+2	6

MEDICAL RADIATION PHYSICS

Elective course \Semester	**CODE**	**VI L+E**	**VII L+E**	**VIII L+E**	**(E)CTS CREDITS**
Laser physics fundamentals	**PTH6411**	2+1			4
Fundamentals of chaos theory	**PTH6421**	2+1			4
Advanced course of optics	**PTH6431**	2+1			4
Electrical measurements of non-electric quantities	**PCM6411**	2+1			4
Physics of ionizing radiation I	**PAP7521**		2+2		5
Medical radiation physics I	**PAP7531**		2+2		5
Radiological protection	**PAP7411**		2+1		4
Physics of ionizing radiation II	**PAP8621**			2+2	6
Medical radiation physics II	**PAP8631**			2+2	6

PHYSICS EDUCATION

Elective course \Semester	**CODE**	**VI L+E**	**VII L+E**	**VIII L+E**	**(E)CTS CREDITS**
General Psychology	**POT4411**	2+1			4
Physics Education I	**PED5611**		4+2		6
Laboratory in Physics Education I	**PED5411**		0+3		4
General Pedagogy	**POT3411**		2+1		4
Physics Education II	**PED6611**			4+2	6
Laboratory in Physics Education II	**PED6311**			0+3	3
Didactics	**POT8411**			2+1	4

I YEAR

(I i II semester)

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**MECHANICS**			
Course ID	Semester	Course status	ECTS credits	L+E
PHY1711	**I**	**MANDATORY**	**7**	**3+3**
Lecturer	**Prof. dr. Elvedin Hasović**			
Aims and intended learning outcomes	The goal of the course is to give students basic knowledge about motion of point-like and rigid bodies, their interaction, as well as the laws of classical mechanics and their application. At the end of the course the student should be able to: -describe the motion of the body in various representations; -apply the laws of mechanics; -solve numerical and conceptual problems in mechanics.			

Course content

Physical quantities and units. Vectors. The position of the body in space - the reference frame. The particle model. Displacement vector and particle velocity. Acceleration. Circular motion. Angular velocity and angular acceleration. Tangential and radial components of acceleration. Graphical representation of the motion. Concept of force. Newton's laws of mechanics. Motion with constant force. Inertial and non-inertial reference frames. Energy, work and power. Kinetic energy. Conservative and non-conservative forces. Potential energy. Conservation of Mechanical Energy. Mechanics of the many-particle system. Momentum. Collisions. Kepler's laws. Newton's law of gravity. Gravitational field. Motion in the gravitational field. Gravitational potential energy. Escape speed. Rotation of a rigid body. Rotation around the fixed axis. Work, power and energy of rotation. Mechanical equilibrium. Angular momentum. Rolling motion. Elasticity. Elastic deformation energy. Fluid mechanics. Bernoulli equation. Real fluids.

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Points
Exam preparation	85	Course Test	50
Total	175	Final Exam	50
		Total	100

Literature

1. Lecture Notes.
2. C. Kittel, W. D. Knight, M.A. Ruderman, *Mehanika*, Tehnička knjiga Zagreb, 1982
3. L. Tanović, N. Tanović, *Fizika : mehanika, oscilacije, talasi*, Svjetlost Sarajevo, 1987
4. S. Bikić, *Zbirka riješenih zadataka iz fizike*, Zenica : Dom štampe, 1998
5. D. Halliday, R. Resnick, and J. Walker, *Fundamentals of Physics,* Wiley, Hoboken, NJ, 2013.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICAL MEASUREMENTS I**			
Course ID	Semester	Course status	ECTS	L+E
PHY1611	**I**	**MANDATORY**	**6**	**3+2**
Lecturer	**Doc. dr. Amra Salčinović Fetić**			
Aims and intended learning outcomes	Course objective is to familiarize students with different experimental techniques and measuring methods of physical quantities as well as to develop their skills to independently conduct experiments, acquire and process data. Learning outcomes: 1. Understands experimental techniques for examination of physical quantities in the fields of mechanics, thermal science and vacuum technique 2. Is familiar with basic elements of vacuum system and their usage 3. Can independently make assessments and calculations in order to plan an experiment as well as to correctly process results of the experiment			

Course content

Importance of measurements in physics. Measurements and errors. International System of Units-definitions of base units. Classification of errors. Mean value. Direct measurements errors. Indirect measurements errors. Normal distribution. Data analysis based on normal distribution of random errors. Graphical analysis of data. Least square method. Measurements in mechanics. Measurements of mass. Cavendish experiment. Methods for measurements of acceleration due to gravity. Methods for determination of elastic properties. Tensometers. Methods for determination of torsion module. Methods for determination of moment of inertia. Temperature measurements. Formation of temperature scale. Types of thermometers. Thermocouples. Thermostats. Introduction to vacuum technique. Elements of the vacuum system. Production of vacuum. Types of vacuum pumps. Measurement of vacuum. Vacuum gauges.

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

Literature

1. T. Čajkovski, D. Čajkovski: Fizikalna mjerenja, I i II, skripta
2. V. Vučic: Mjerenja u fizici, Naučna knjiga, Beograd, 2003.g.
3. S. Marić, Fizika, Svjetlost, Sarajevo, 2003. g.
4. A. Saveljev, Fizika I i II
5. W. F. Sears: Mehanika, talasno kretanje i toplota
6. F.W.Sears: Elektricitet i magnetizam, Naučna knjiga, Beograd, 1963.
7. G. Dimić, M. Mitrinović: Metrologija u fizici, Građevinska knjiga Beograd 1990.g

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics physics**	
Course name	**LINEAR ALGEBRA FOR PHYSICISTS**			
Course ID	Semester	Course status	ECTS credits	L+E
POT1711	**I**	**MANDATORY**	**7**	**3+3**
Lecturer				
Aims and intended learning outcomes	The aim of the course is that students learn mathematical operations with vectors and matrices, and with linear operators in general. It is expected that student knows operations with vectors and matrices, and their various applications (solving linear equations, transformations, etc.); Student is familiar with properties of Euclid space, curves and surfaces of the second order.			

Course content
Vectors in the two and three-dimensional space. The scalar product of the vector and application. Vector (cross) product and application. The mixed product and application. Lines and planes in a three-dimensional space. Systems of linear equations, linear independence, criteria for the existence of unique solutions. Matrices, matrix operations, matrix equations.. Elementary matrices, the inverse of a matrix, Symmetric matrices and Quadratic forms. Determinants. Vector space. The Gram - Schmidt process. Linear operators, linear transformations. Eigenvectors and Eigenvalues. Second-order curves and surfaces.

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Points
Exam preparation	85	Midterm exam	50
Total	175	Final exam	50
		Total	100

Literature
1. A. Odžak, S. Odžak, Linearna algebra i analitička geometrija (sa primjenama), Univerzitet u Sarajevu 2017. 2. Notes from the lectures. 3. D.C. Lay, Linear algebra and its applications, Pearson education 2002.

Remarks

Program	Level of studies	**First cycle**
	Program name	**Physics**
Course name	**MATHEMATICAL ANALYSIS FOR PHYSICISTS I**	

Course ID	Semester	Course status	ECTS	L+E
POT1721	**I**	**MANDATORY**	**7**	**3+3**

Lecturer	**Prof. dr. Nacima Memić**
Aims and intended learning outcomes	The ability to deal with differential calculus. Application of calculus in physics problems. The ability to use various convergence tests. The ability to describe the behaviour of differentiable functions.

Course content

1. Axioms of the set of real numbers
2. Mathematical induction- Rational and irrational numbers
3. The nested intervals theorem-Accumulation point theorem
4. Sequences-Limits- Number e
5. Series and sums
6. Series with positive terms
7. Convergence criteria of series
8. Real functions-Limits
9. Continuous functions- Elementary functions
10. Notion of derivative- Basic rules-
11. Higher order differentials
12. Basic theorems on calculus
13. L'Hopital rule
14. Taylor Formula
15. Convex functions

Student workload (hours)		Grading	
		Assessment method	Points
Lectures and Exercises	90	Tests during course	50
Exam preparation	85	Final exam	50
Total	175	Total	100

Literature

1. V. A. Zorich, Mathematical analysis I, Universitext, Springer, Berlin, 2003.
2. I. Ljaško i dr., Zbirka zadataka iz matematičke analize, IBC ’98, 2002.

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">OSCILLATIONS, WAVES AND FUNDAMENTALS OF THERMODYNAMICS</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>PHY2711</td><td>II</td><td>MANDATORY</td><td>7</td><td>3+3</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 give students basic knowledge about oscillatory motion, mechanical waves, as well as the laws of thermodynamics land their application.

At the end of the course the student should be able to:

-describe the oscillatory motion of a harmonic oscillator;
-understand the concept of wave motion and explain the interference and diffraction of waves;
- apply the laws of thermodynamics;
- solve numerical and conceptual problems in the topics of oscillations, waves and thermodynamics.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Oscillatory motion. The energy of a harmonic oscillator. Damped oscillations. Driven oscillations. Resonance. Travelling waves. Speed of a wave.Energy of a wave. Doppler effect. Wave diffraction. Wave interference. Sound waves. Thermodynamic systems and thermodynamic parameters. Temperature. Ideal gas. Ideal gas equation. Thermal expansion. Internal energy. Heat. Work. The first law of thermodynamics. Heat capacity. Adiabatic processes of ideal gas. Phase changes. The second law of thermodynamics. Heat engines. Heat pumps. Carnot's cycle. Carnot's theorem. The Clausius Theorem. Entropy. Molecular-kinetic theory of gases. Degrees of freedom. Absolute temperature from the point of view of molecular-kinetic theory. Distribution of energy by degrees of freedom. Maxwell-Boltzmann distribution. Transport phenomena in gases. Viscosity of gases. Thermal conductivity of gases. Diffusion of gases.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Points
Exam preparation	85	Course Test	50
Total	175	Final Exam	50
		Total	100

Literature

1. Lecture Notes.
2. L. Tanović, N. Tanović, *Fizika - mehanika, oscilacije, talasi*, Sarajevo: Svjetlost, 1990
3. E. Hadžiselimović, *Osnovi termodinamike i molekularne fizike*, Tuzla : Bosnia Ars, 2005
4. L. Tanović, N. Tanović, *Fizika - osnove termodinamike i molekularno-kinetičke teorije gasova*, Sarajevo: Svjetlost, 1988
5. S. Bikić, *Zbirka riješenih zadataka iz fizike*, Zenica : Dom štampe, 1998
6. D. Halliday, R. Resnick, and J. Walker, *Fundamentals of Physics,* Wiley, Hoboken, NJ, 2013.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICAL MEASUREMENTS II**			
Course ID	Semester	Course status	ECTS	L+E
PHY2511	**II**	**MANDATORY**	**5**	**2+1**
Lecturer	**Doc. dr. Amra Salčinović Fetić**			
Aims and intended learning outcomes	Main course aims are to familiarize students with the different techniques and methods of physical quantities measurement, as well as to develop skills of experiment realization, data collection and solving of problems in measurements and testing. By completing this course, students will gain fundamental knowledge about measurements of the electrical, optical and acoustical quantities. Also students have to understand the work principle of electrical measurements devices, know how to use them properly as well as to independently estimate and evaluate the necessary calculations in the planning of the experiment.			

Course content

Measurements in electromagnetism: Main terms and definitions. Electromechanical instruments for measurement of current and voltage. Moving coil instrument. Galvanometers. Motion of moving coil in a galvanometer. Ballistic galvanometer. Moving iron instruments. Electrical measurements of non-electrical quantities. Sensors. Analogue and digital measurements. Oscilloscope. Methods for the measurement of electrical resistance. U-I method. Wheatstone bridge. Measurement of low resistance. Substitution method. Electrical shunt. Universal Ayrton shunt. Ammeter as voltmeter. Ohmmeter. Measurement of the internal resistance of galvanic cells. Potentiometers. Compensation method. Wulf electrometer. Methods for the measurement of electrical capacitance. Thomson's method. De Sauty's method. A.C. bridges. Measurement of capacitance by Schering's bridge. Measurement of capacitance by Wien's bridge. Robinson's frequency bridge. Owen's bridge for measurement of inductance. Measurements in Optics: Basic terms and definitions. Methods for measuring the speed of light. Methods for measuring refractive index. Photometry: Basic terms and definitions. Illumination of a surface by point light source. Photometers. Visual photometers. Objective photometers. Acoustics: Basic terms and definitions. Measurement of sound velocity. Measurement of Galton's whistle frequency by Quincke's tube.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	30	Homework	10
Assignments	20	Midterm exam	50
Consultation	30	Final exam	40
Total	125		
		Total	100

Literature

1. S. Sulejmanović, A. Salčinović Fetić: Fizikalna mjerenja: primjeri mjerenja iz elektromagnetizma, optike i akustike, PMF Sarajevo, 2016.
2. F.W.Sears: Elektricitet i magnetizam, Naučna knjiga, Beograd, 1963.
3. G. Dimić, M. Mitrinović: Metrologija u fizici, Građevinska knjiga Beograd 1990.
4. S. Marić, Fizika, Svjetlost, Sarajevo, 2003.

Remarks

Midterm exam – 9th week of classes

<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">MATHEMATICAL ANALYSIS FOR PHYSICISTS 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>POT2811</td><td>II</td><td>MANDATORY</td><td>8</td><td>3+4</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Nacima Memić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The ability to calculate and use integrals in various applications
Application of the notions of integrals in physics problems
To deal with various techniques for calculating integrals
The ability to use integration in physics problems</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">1. Integration table - Integration methods
2. Integration of rational and trigonometric functions
3. Integration of irational functions- Binomial integral
4. Definite integral - Riemann sum
5. Riemann integrabity criterion
6. First mean value theorem for integrals
7. fundamental theorem of calculus
8. Change of variables in definitie integral
9. Second mean value theorem for integrals
10. Area of a plane surface- Volume of a rotating solid
11. Arc length formula - Area of a rotating curve
12. Ordinary and uniform convergence of a sequence of functions
13. Properties of uniformly convergent series of functions
14. Power series - Convergence radius of power series
15. Differentiation and integration of power series</td></tr>
</table>

Student workload (hours)		Grading	
		Assessment method	Points
Lectures and Exercises	90	Tests during course	50
Exam preparation	110	Final exam	50
Total	200	Total	100

Literature

1. V. A. Zorich, Mathematical analysis I, Universitext, Springer, Berlin, 2003.
2. I. Ljaško i dr., Zbirka zadataka iz matematičke analize, IBC ’98, 2002.

Remarks

Program	Level of studies	**First cycle**
	Program name	**Physics**

Course name	**PHYSICS LABORATORY I**			
Course ID	Semester	Course status	ECTS credits	L+E
PHY2411	**Second (II)**	**MANDATORY**	**4**	**0+3**
Lecturer	**Prof. dr. Elvedin Hasović**			

Aims and intended learning outcomes

The aim of the course is to familiarize students with practical laboratory exercises as well as with phenomena and physical laws in the field of mechanics by handling and using different devices and instruments.

Students are expected

- to be able to apply the experimental methodology to the research of physical phenomena in the field of mechanics,
- to be able to master the operation of the apparatus for demonstrating certain mechanical phenomena,
- explain the difference between the obtained and the expected results in the experiments.

Course content

1. An introduction. The basic instructions for laboratory work.
2. Measurement of length and volume.
3. Measuring the surface.
4. Determining the acceleration of gravity.
5. Determining the initial velocity of horizontally launched ball.
6. Determining the density of solid bodies.
7. Determining the density of liquid.
8. Determining the moment of inertia.
9. Elastic deformations of solid bodies.
10. Determination of viscosity coefficient using a single capillary viscometer - absolute method. Two-capillary viscometer
11. Determination of viscosity coefficient with two-capillary viscometer - absolute and relative method.
12. Standing acoustic waves.
13. Repetition: Measurement for tasks with a large measurement error.
14. Verification of validation exercises.
15. Midterm.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Bodovi
Exam preparation	45	Midterm exam	16
Assignments	5	Exercises	44
Other	5	Final exam	40
Total	100		
		Total	100

Literature

1. Praktikum iz mehanike – interna skripta, PMF Sarajevo.
2. G. L. Dimić, M. D. Mitrinović, Metrologija u fizici: viši kurs, Beograd: Građevinska knjiga, 1990.

Remarks

Study program	Cycle	**First cycle**
	Study program	**Physics**
Physics	**GENERAL CHEMISTRY FOR PHYSICISTS**	

Course code	Semester	Course type	ECTS credits	L+PW
POT2411	**II**	**MANDATORY**	**4**	**2+1**

Assigned Lecturers	**Prof. dr. Sabina Begić**
Aims and intended learning outcomes	Introducing students with basic chemistry concepts in the field of compounds naming, chemical bonds, solution properties, energy changes and electrochemistry.

Course syllabus

1. Types of substances. Separation of substances into pure substances. Properties and types of pure substances. Work in the chemical laboratory.
2. Relative atomic mass. Relative molecular mass. Mole.
3. Solutions and their properties. Quantitative calculations of solution composition. Decantation, distillation, filtration.
4. Diffusion and osmosis. Electrolyte solutions.
5. Colloid-dispersive systems. Colloids.
6. Periodic system of the elements.
7. General properties of the elements (atom size, ionisation energy, electron affinity, electronegativity, polarisation ability and polarisability, coordination number and oxidation state.) Molar mass determination (CO_2 or metal)
8. Classification of elements (s-, p-, d- and f- elements). Electrolytes. Galvanic elements.
9. Chemical bond – ionic, covalent.
10. Chemical bond – energy of covalent bond. Allotropy and isomorphism. Types of chemical reaction.
11. Energy changes in chemical reactions.
12. Main classes of inorganic compounds.
13. Concept of chemical equilibria in homogenous and heterogenous systems. Chemical equilibria.

Student workload (hours)		Assessment of knowledge and grading scale	
Literature and practical work	30+15	Grading scheme	Points
Exam study time	55	Attendance	5 (minimum 3)
Written papers	-	I exam	27,5 (minimum 15)
Other (state)	-	II exam	27,5 (minimum 15)
Total	100	Final exam	40 (minimum 22)
		Total	100 (minimum 55)

LITERATURE

MANDATORY
1. Ivan Filipović, Stjepan Lipanović, Opća i anorganska hemija I dio, Školska knjiga Zagreb,1995.

RECOMMENDED
1. Emira Kahrović, Anorganska hemija, Bemust, 2005, Sarajevo
2. Praktikum iz opšte hemije, interna skripta

Napomene

II YEAR

(III i IV semester)

Program	Level of studies	**First cycle**
	Program name	**Physics**

Course name	**ELECTROMAGNETISM**			
Course ID	Semester	Course status	ECTS credits	L+E
PHY3611	**III**	**MANDATORY**	**6**	**3+2**
Lecturer	**Prof. dr. Senad Odžak**			
Aims and intended learning outcomes	The objective of the course is to introduce students through lectures and auditory exercises with phenomena in the field of Electromagnetism. 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

Coulomb's law. Electric field. Gauss's law and its applications. Electric potential. Capacity. Dielectrics. Electric current. Electrical conduction in liquids and gases. Kirchhoff's circuit laws. Magnetism. Magnetic property of matter. Biot-Savart's law. Ampere's law. Inductance. Electromagnetic induction. Alternating current. RLC circuit.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	70	Course Test	60
Assignments	0	Final Exam	40
Other	5		
Total	150		
		Total	100

Literature

1. Lecture Notes
2. F.W. Sears, Elektricitet i magnetizam, Naučna knjiga, Beograd, 1962.
3. Nikola Cindro: Elektricitet i magnetizam, Školska knjiga, Zagreb, 1988.
4. I. Bleaney and B. Bleaney: Electicity and Magnetism, Oxford University Press, Oxford, 1993.
5. S. Grant and W. R. Phillips: Electromagnetism, John Wiley & Sons, Chichester, 1995.

Remarks

Partial and final exam consists of a theoretical part and multiple assignments. The maximum number of points in the theoretical part and assignments is 30 and 20, respectively. 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		**First cycle**	
	Program name		**Physics**	
Course name	**CLASSICAL MECHANICS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH3711	**III**	**MANDATORY**	**7**	**3+3**
Lecturer	**Prof. dr. Azra Gazibegović - Busuladžić**			
Aims and intended learning outcomes	Aim of the course is to teach students the principles of Classical mechanics and apparatus for particle and general holonomic system motion. After successfully completed this course, student will know how to: - Describe and solve particle motion problems in different curvilinear coordinate systems. - Analyze particle central force motion, particularly for inverse square force, and knows how to interpret an effective potential graph. - Student is familiar with dynamic laws for system of particles and characteristic physical quantities, and methods for solving problems of dynamic of particle system with constrains. - Student is familiar with Lagrangian mechanics.			

Course content

Subject, basic concepts and limits of the applicability of Classical mechanics. Kinematics of a particle: mathematical description of the motion, basic kinematic quantities. Curvilinear coordinates. Principles of dynamics: Newton's laws, the principle of determinism, Galilean's principle of relativity. Dynamics of the material particles: differential equations of motion, integrals of motion. Basic dynamic quantities: momentum, angular momentum, kinetic energy, work. Potential Energy and Conservative Forces. Force as the Gradient of Potential Energy. Rectilinear motion, Energy diagrams. Central motion: solution of the equations of motion in polar coordinates, Effective potential, Energy diagrams. Binet's formula. Particle in gravitational or Coulomb field. Particle scattering by a central potential.

Particle system dynamics: differential equations of motion, internal and external forces. Momentum, Center of mass, Angular momentum, Mechanic energy of the system. König's formula - dynamic quantities in the center of mass reference frame. Closed systems, classical integrals of motion. The virial theorem. Variable mass systems: the rocket equation. Two-Body Central-Force Problems. Relative Coordinates, Reduced Mass.

Constrained systems: constraints and normal forces, classification. Possible and virtual displacements, ideal constraints, d'Alembert's principle, Lagrange's equations of the first kind. Motion of a particle on a smooth surface and a smooth line, determination of the Lagrange multipliers. Spherical and mathematical pendulum. Lagrange mechanics: generalized coordinates, Lagrange's equations of the second kind, Lagrange function. Integrals of motion: ignorable coordinates, general energy *H*. Velocity-dependent potentials, appropriate examples. Lagrange equations structure.

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Points
Exam preparation	85	Midterm exams	55
Total	175	Final exam	45
		Total	100

Literature

1. K. Suruliz, Klasična mehanika, FLAMMULA,2013
2. Corresponding material from the web-site "e-nastava" and notes from the lectures

Additional readings:

1. H. Goldstein, C. Poole, J. Safko, Classical Mechanics, Third Edition, Pearson/Addison-Wesley, Upper Saddle River 2002
2. John R. Taylor, Classical Mechanics, University Science Book, 2005

Remarks

The final exam is oral when possible. Students must score a minimum of 55% of the tests in order to enter the final exam. In order to successfully pass at the final exam, the student must score at least 50% of the points, with the total score at least 55 points.

Program	Level of studies	**First cycle**
	Program name	**Physics**

Course name	**MATHEMATICAL METHODS OF PHYSICS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PCS3011	**III**	**MANDATORY**	**10**	**4+4**
Lecturer				
Aims and intended learning outcomes	Introducing students to mathematical methods used in general and theoretical physics. After completing the course student will be able to solve problems in courses of theoretical physics at senior years.			

Course content

The Calculus of a function of several variables
Function of two and more variables: continuity, limits and differentiability, partial derivatives, geometrical interpretation of partial derivatives, higher partial derivatives, total differential tangent plane and linear approximation, the chain rule, Taylor's expansion, directional derivatives, gradient vector, maximum and minimum values, methods of Lagrange's multipliers.
Double integrals: Double integrals over rectangles and general regions, application of double integrals in mechanics (calculation of a surface area in a plane, volume, mass, moment of a inertia, surface area and centre of a mass of a solid), coordinate transformation in double integrals.
Triple and multiple integrals: triple integrals in physics (volume, mass, centre of a mass, moment of inertia, electrostatic potential, gravity force), coordinate transformations in triple integrals, using spherical, cylindrical and general coordinates to calculate triple integrals.
Vector calculus
Vectors field in physics, gradient, curl and divergence, potential field in physics, parametric curves, line integrals, Green's theorem, work of a vector field, conservative fields in physics, parametric surfaces surface integrals, Stoke's theorem and Gauss' theorem with application in physics (mass flux, heat flux, magnetic and electric field flux, etc).
Differential equations
Linear differential equation of first and second order, differential equations of constant coefficients, general and particular solution, examples of differential equations in physics (Newton's equations of motion, RLC circuit, damped nad forced linear harmonic motion, etc), Bernouli's and Riccati's differential equation, the variation of a constant method, series solution of differential equation, simple pendulum oscillations, systems of differential equations.

Student workload (hours)		Grading	
Lectures and Exercises	120	Assessment method	Points
Exam preparation	100	Midterm exam	50
Assignments	10	Final exam	50
Other	20		
Total	250		
		Total	100

Literature

1. Mirza Hadžimehmedović, Milan Pantić, *Matematičke osnove teorijske fizike I*,PrintCom, Tuzla, 2015.
1. James Stewart, *Calculus*, Thomson Learning – Brooks/Cole, 5th Edition, 2003.
2. V. Ilin, E. Poznyak, *Fundamentals of mathematical analysis*, Mir Publishers, Moscow, 1982.
3. D. Mihailović, D. Tošić, *Elementi matematičke analize II*, Naučna knjiga, Beograd, 1983.
4. M. P. Uščumlić, P. M. Miličić, *Zbirka zadataka iz više matematike II*, Naučna knjiga, Beograd.

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 LABORATORY II</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>PHY3311</td><td>III</td><td>MANDATORY</td><td>3</td><td>0+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 aim of the course is to familiarize students with practical laboratory exercises as well as with phenomena and physical laws in the field of thermodynamics.

Students are expected to:
1. gain self-confidence in handling laboratory equipment
2. learn the basic methods of physical quantities measurments in the field of thermodynamics
3. colect acceptable data by measuring, analyze them, interpret the obtained results and draw the appropriate conclusions</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Surface tension
Thermal expansion of solids
Gas processes
Basic calorimetric measurments
Specific heat capacity of metals and gases
Phase transitions
Thermal conductivity
Determination of the convective heat transfer coefficient</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>30</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>30</td><td>Laboratory reports</td><td>40</td></tr>
<tr><td>Assignments</td><td>10</td><td>Test</td><td>20</td></tr>
<tr><td>Other</td><td>5</td><td>Final practical exam</td><td>40</td></tr>
<tr><td>Total</td><td>75</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. Uputstva za vježbe „Fizikalni praktikum II“ (interna skripta), Prirodno-matematički fakultet, Sarajevo.
2. Hadžiselimović, E. (2005), Osnove termodinamike i molekularne fizike, bosniaARS, Tuzla.
3. Tanović, L., Tanović, N. (1988), Fizika: Osnove termodinamike i molekularno-kinetičke teorije gasova, Svjetlost, Sarajevo.
4. Dimić, G. L. (1990), Metrologija u fizici D viši kurs, DP Građevinska knjiga, Beograd.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Program	Level of studies	**First cycle**
	Program name	**Physics**
Course name	**PHYSICS LABORATORY III**	

Course ID	Semester	Course status	ECTS credits	L+E
PHY3411	**IV**	**MANDATORY**	**4**	**0+3**

Lecturer	**Prof. dr. Senad Odžak**
Aims and intended learning outcomes	The aim of the course is that students get familiar with phenomena and physical laws of electricity and magnetism, through practical laboratory exercises, as well as operating and using electrical devices and instruments. It is expected that students gain confidence in handling laboratory equipment and be capable of that on the basis of instruction, control the work of the apparatus and gain results which should be approached with criticism.

Course content

1. An introduction. The basic instructions for work in laboratory for electromagnetism, explaining the duties, the prearrangement of work, getting familiar with the plan and the program of the course.
2. Electrostatic field. An entrance colloquium.
3. Electric resistance. Colloquy of the first finished exercise.
4. The sources of constant electromotive force. Colloquy of the second finished exercise.
5. Measuring inductivity and capacity. Colloquy of the third finished exercise.
6. Geomagnetic measurements. Colloquy of the fourth finished exercise.
7. Electronic tube – triode. Colloquy of the fifth finished exercise.
8. Midterm exam. Colloquy of the sixth finished exercise.
9. Determination of resistance and capacity in a circuit with alternating current using graphical method. An entrance colloquium.
10. Energy of alternating current. Colloquy of the first finished exercise.
11. Cathode oscilloscope. Colloquy of the second finished exercise.
12. Electromagnetic measurements. Colloquy of the third finished exercise.
13. Ferromagnetism. Colloquy of the fourth finished exercise.
14. Electromotor and generator. Colloquy of the fifth finished exercise.
15. Colloquy of the sixth finished exercise.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Bodovi
Exam preparation	30	Midterm exam	38
Assignments	15	Exercises	24
Other	10	Final exam	38
Total	100		
		Total	100

Literature

1. N. Gabela, Z. Hadžibegović, A. Gazibegović Busuladžić, L. Gabela, Praktikum iz elektromagnetizma, Sarajevo, 2007.
2. V. Vučić, Osnovna mjerenja u fizici, Beograd, Naučna knjiga, 1998.

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">OPTICS</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>PHY4611</td><td>IV</td><td>MANDATORY</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Mustafa Busuladžić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The goal of this course is to understand the fundamental properties of light propagation and interaction with matter under the approximations of geometrical optics and scalar wave optics.

At the end of the course the student should be able to:
-state the Fermat’s principle and use it to derive the laws of optics;
-derive the mirror and lens equations and use them to solve various problems;
-describe the main optical instruments and explain how they work;
-explain the properties of the light by using the principles of wave optics;
-explain and analyze the interference, diffraction and polarization of light.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Fermat's principle and its applications. Ray optics. Paraxial approximation. Rectilinear propagation of light. Reflection and refraction. Total internal reflection. Plane and spherical mirrors. Spherical mirror equation. Object, image, and magnification. Sign convention. Graphical methods. Aspherical mirrors. Dispersion by a prism. Dispersive power. Angular and chromatic dispersions. Combination of prisms. Refraction through a compound slab. Refraction at spherical surfaces. Lateral and longitudinal magnification. Smith-Helmoltz equation and Lagrange law. Abbe's sine condition. Applanatic points.
Lenses. Image tracing and sign convention. Thin lens. Lens maker's equation. Newton's lens equation. Magnification. Power. Optical system and cardinal points. Construction of the image using cardinal points. Thick lenses. Cardinal points of thick lenses. Thick lens equation. Combination of two thick lenses. Lens aberrations. Optical instruments. Photometry.
Wave optics. Propagation of light waves. The Fresnel equations. Polarization of light. Brewster's law. Linear polarization. Malus' law. Anisotropic cristals. Double refraction in crystal. Huygens' explanation of double refraction. Electromagnetic theory of double refraction. Optical indicatrix. Elliptically and circularly polarized light. Analysis of polarized light. Optical activity and Fresnel's explanation. Interference. Young's double slit experiment. Coherence (coherence length and coherence time). Conditions for interference. Techniques for obtaining interference. Interference in thin films. Interference due to reflected light. Conditions for minima and maxima. Interference due to transmitted light. Variable thickness film. Colours in thin films. Newton's rings. Types of diffraction. Fresnel diffraction. Huygens-Fresnel theory. Zone plate. Distinction between interference and diffraction. Fraunhoffer diffraction at a single slit. Fraunhoffer diffraction at a circular aperture. Fraunhoffer diffraction at double slit. Plane diffraction grating.</td></tr>
</table>

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

Literature

1. Lecture Notes.
2. Eugene Hecht, Optics, fifth ed., Pearson, London, 2016.
3. F. W. Sears, Optika, prijevod trećeg izdanja, Naučna knjiga, Beograd, 1963.
4. F. L. Pedrotti, L. M. Pedrotti, L. S. Pedrotti, Introduction to optics, third ed., Pearson, London, 2014.
5. G. S. Landsberg, Optika, prijevod četvrtog izdanja, Naučna knjiga, Beograd, 1967.

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.

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**INTRODUCTION TO ATOMIC PHYSICS**			
Course ID	Semester	Course status	ECTS credits	L+E
PHY4511	**IV**	**MANDATORY**	**5**	**2+2**
Lecturer	**Doc. dr. Maja Đekić**			
Aims and intended learning outcomes	Course objective is to familiarize students with phenomena and physical laws at the atomic level. Learning outcomes: 1. Knows and understands phenomena and physical laws at microscopic level 2. Applies this knowledge to independently solve problems from this field 3. Can successfully attend and understand further courses throughout the study			

Course content

Review of ideas that led to development of atomic physics. THERMAL RADIATION. Definition of black body. Black body emission and absorption. Laws of thermal radiation: Kirchhoff, Stefan-Boltzmann, Wien and Rayleigh-Jeans formula. UV catastrophe. Planck's law. Idea of photon. QUANTIZATION OF PHYSICAL WORLD-Quantization of electricity. Discovery of electron. Thompson and Millikan experiments. Quantization of energy. Photons. Photoelectric effect. Einstein's formula for photoelectric effect. X-rays. Spectrum of X-rays. Atomic spectra. ELEMENTS OF THE SPECIAL THEORY OF RELATIVITY-Transformation of coordinates. Dilatation of time. Contraction of length. Mass and energy. Compton effect. MODELS OF ATOM- Thompson's static model. Rutherford's experiment with alpha particles. Rutherford's atomic model. BHOR'S THEORY OF HYDROGEN ATOM- Line spectra. Bhor's postulates. Energy levels. Application of Bhor's theory to atoms similar to hydrogen. Frank-Hertz experiment. Moseley's law. IMPROVEMENT OF BHOR'S MODEL. Wilson-Sommerfeld quantization rules. Eliptical model. Space quantization. QUANTUM MECHANICAL ATOMIC MODEL. Matter waves-de Broglie wave length. Davisson-Germer experiment. Heisenberg uncertanty principle. VAWE FUNCITON AND PROBABILITY, QUANTIZATION OF ENERGY-Schrodinger equation. QUANTUM NUMBERS-Quantization of energy. Source and meaning of quantum numbers. Stern-Garlach experiment. PERIODIC TABLE OF ELEMENTS-Pauli's principle of exclusion. Dimensions of atoms.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	65	Test	50
Assignments		Final exam	50
Other			
Total	125		
		Total	100

Literature

1. N.Tanović i L.Tanović: OSNOVE ATOMSKE I NUKLEARNE FIZIKE, Uniprint Sarajevo, 1991.

Remarks

Program	Level of studies	**First cycle**
	Program name	**Physics**
Course name	**CLASSICAL MECHANICS II**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH4711	**IV**	**MANDATORY**	**7**	**3+3**

Lecturer	**Prof. dr. Azra Gazibegović - Busuladžić**
Aims and intended learning outcomes	The aim of the course is to teach students how to analyze and solve the motion of a rigid body; mechanics in noninertial frames; relation of the equations of classical mechanics with the equations of modern physics through variational principles and Hamilton formalism. After mastering the subject, a student knows how to: - Describe and solve the motion of a rigid body; - Analyze and solve the equations of motion for a system that performs small oscillations. - The student knows the Variational principles and Hamilton's formalism.

Course content

Rotational motion of rigid body: Kinematics. Translational and rotational motion. Angular velocity. Eulerian angles.
Mechanics in noninertial frames: kinematics and dynamics, inertial forces. Examples: free fall, Foucault's pendulum.
Rigid body dinamics. Rotation about a fixed axis: moment of inertia, physical pendulum. Rotation about a fixed point: equations of motion, inertia tensor, principal axes and principal moments of inertia, Euler's equations, free precession, inertia ellipsoid. Some special cases. General rigid body motion, examples.

Small oscillations, Coupled oscillators, normal modes and normal coordinates. Forced oscillations, damped oscillations. Driven damped oscillations.
Variational principles of mechanics: Hamilton's principle, Maupertuis-Lagrange-Jacobi's principle. The Catenary. Fermat's principle.
Hamiltonian mechanics. Hamilton's equations. Poisson brecket. Canonical transformations, Hamilton-Jacobi equation. Symmetries and conservation laws. E. Noether 's theorem.
Longitudinal oscillations of the system of springs. Introduction to continuum mechanics. Elastic string. Lagrange's and Hamilton's equations. Transverse motion of a taut string.

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Bodovi
Exam preparation	85	Midterm exam	55
Total	175	Final exam	45
		Ukupno	100

Literature

1. K. Suruliz, Klasična mehanika, FLAMMULA, 2013
2. Corresponding material from the web-site "e-nastava" and notes from the lectures

Additional readings :

1. H. Goldstein, C. Poole, J. Safko, Classical Mechanics, Third Edition,Pearson/Addison-Wesley, Upper Saddle River 2002
2. John R. Taylor, Classical Mechanics, University Science Book, 2005

Remarks

The final exam is oral when possible. Students must score a minimum of 55% of the tests in order to enter the final exam. In order to successfully pass at the final exam, the student must score at least 50% of the points, with the total score at least 55 points.

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**MATHEMATICAL METHODS OF PHYSICS II**			
Course ID	Semester	Course status	ECTS credits	L+E
PCS4011	**IV**	**MANDATORY**	**10**	**4+4**
Lecturer	**Prof. dr. Azra Gazibegović - Busuladžić**			
Aims and intended learning outcomes	Aim of this course is to familiarize students with a range of mathematical methods that are essential for solving advanced problems in theoretical physics. **After successfully completed course, student will be able to** use complex analysis in solving physical problems; use Fourier series and integral transformation; use Green functions; solve Sturm-Liouvill's problem and partial differential equations of second order that are common in the physical sciences; use the orthogonal polynomials and specific special functions in physical problems; use the calculus of variations; solve some types of integral equations.			

Course content

Complex algebra; complex functions; Cauchy-Riemann conditions; line integral; Cauchy's integral theorem; Cauchy's integral formula and it's applications; Complex function series; Uniform convergence. Taylor expansion; analytic extension; poles of the function; determination of residues; Laurent development; mapping; cut line, branch point and multi-valued functions; conformal mapping; singularities; Residue Theorem; Cauchy principal value; Jordan's lema. Dispersion relations. Euler's functions (Beta and Gamma). Laplace transformation. Fourier transformation and uncertanity principle. Dirac delta function; Sine and cosine transformations. Convolution teorem. Parseval's theorem.

Fourier series. Dirichlet conditions. Spectroscopy. Partial differential equations and physical problems: Laplace eq., Poisson's eq., wave eq. e.t.c. General solution. Separation of variables; Regular S-L problem; self-adjoint differential equations; hermitian operators, Gram-Schmidt orthogonalization process; orthogonal polynomials; completeness of the eigenfunctions; Bessel's inequality. Green's function, expansion of Green's functions; Green's function for LHO. Schroedinger equation for hidrogen atom: Legendre polynomials; associated Legendre polynomials; Spherical function; Multiple moments; Laguerre polynomials; associated Laguerre polynomials; Quantum mechanics LHO: Hermite polynomials; Bessel functions; QM scattering and spherical Bessel functions; Calculus of variations; Functionals; Euler-Lagrange equation. Rayleigh-Ritz variational technique. Integral equations, Fredholm's alternative, Liouville- Neumann series.

Student workload (hours)		Grading	
Lectures and Exercises	120	Assessment method	Points
Exam preparation	130	Midterm exams	55
Total	250	Final exam	45
		Total	100

Literature

1. M. Boas, Mathematical methods in the physical sciences, third edition, Wiley 2006
2. Corresponding material from the web-site "e-nastava" and notes from the lectures

Additional readings:

1. K. F. Riley, M. P. Hobson, S. J. Bence, Matemathical methods for physics and engineering, 3rd edition, Cambridge University Press
2. G. Arfken, H. Weber, Matemathical methods for physicists, Elsevier 2005

Remarks

The final exam is oral when possible. Students must score a minimum of 55% of the tests in order to enter the final exam. In order to successfully pass at the final exam, the student must score at least 50% of the points, with the total score at least 55 points.

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICS LABORATORY IV**			
Course ID	Semester	Course status	ECTS credits	L+E
PHY4211	**IV**	**MANDATORY**	**2**	**0+2**
Lecturer	**Prof. dr. Mustafa Busuladžić**			
Aims and intended learning outcomes	The goal of this course is to provide students with a general knowledge of the principles of geometrical and physical optics, and optical instrumentation, as well as a hands-on practice experience through laboratory work. At the end of the course the student should be able to: -handle optical elements and set-up basic optical experiments; -apply basic knowledge of principles and theories about behavior of the light to conduct experiment; -collect and appropriately analyze data working indenpendently and in collaboration with other students.			

Course content

Spherical mirrors.
Converging and diverging lenses.
Optical instruments.
Spectrometry.
Photometry.
Interefrence. Young double-slit experiment. Newton rings.
Fraunhoffer diffraction at a single slit.
Plane diffraction grating.
Polarization.
He-Ne laser.

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	20	Course Test	50
Total	50	Final Exam	50
		Total	100

Literature

1. Lecture notes.
2. Nada Gabela, Praktikum iz optike, drugo izdanje, PMF, Sarajevo, 2000.

Remarks

Continuous knowledge and skills assessment will be carried out through midterm exams. This includes written test as well optics laboratory exam. The laboratory exam is used to assess each student’s ability to make accurate measurements with typical optics lab instruments, analyze and interpret obtained data. The successful completion of the course implies achieving at least 55% of the total number of points in both the partial and final exam.

III YEAR

(V i VI semester)

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**QUANTUM MECHANICS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH5711	**V**	**MANDATORY**	**6**	**3+2**
Lecturer	**Prof. dr. Dejan Milošević**			
Aims and intended learning outcomes	The objective of the course is to introduce students to the basic concepts of quantum mechanics, as well as to enable them to solve tasks from this fundamental field of theoretical physics independently, using new mathematical methods. After presenting the physical basics and mathematical apparatus of quantum mechanics, the developed formalism will be applied to simple quantum mechanical systems. The learning outcome is mastering theoretical knowledge from the basis of quantum mechanics, the adoption of the quantum mechanics formalism, and the acquisition of the ability to understand and independently solve quantum-mechanical problems, which is important for a large number of subjects that a student will encounter during the course of studies.			

Course content

Historical introduction and physical basics of quantum mechanics. Mathematical basics of quantum mechanics. Schrödinger equation. Harmonic oscillator. Transition from classical to quantum mechanics. Spherical symmetric potential. Hydrogen atom. The representation theory.

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, Kvantna mehanika I, 2015. (available at e-learning)

Recommended:
1. L. I. Šif, Kvantna mehanika, Vuk Karadžić, Beograd, 1968.
2. Supek, Teorijska fizika i struktura materije, II dio, Školska knjiga, Zagreb, 1977.
3. W. Greiner, Quantum mechanics. An introduction, Springer, Berlin, 1989.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**THEORY OF ELECTROMAGNETIC FIELD**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH5611	**V**	**MANDATORY**	**6**	**3+2**
Lecturer	**Prof. dr. Senad Odžak**			
Aims and intended learning outcomes	The aim of the course is to introduce students at a more advanced level into classical electrodynamics through lectures and auditory exercises. It is expected that students successfully adopt the content of the course and that the acquired knowledge is successfully applied in further academic education and/or scientific work.			

Course content

Introduction. Electrostatics. Magnetostatics. Maxwell's Equations in Free Space. Maxwell's Equations in Matter. Conservation Laws in Electrodynamics. Electromagnetic Waves in Vacuum.Electromagnetic Waves in Matter. Absorption and Dispersion. Guided Waves. Potentials and Fields. Radiation.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	70	Course Tests (Multiple assignments)	60
Assignments	0	Final Exam (Theory)	40
Other	5		
Total	150		
		Total	100

Literature

1. Lecture Notes
2. David J. Griffiths, Introduction to Electrodynamics, Pearson Education, Glenview, 2013.
3. W. Greiner, Classical Electrodynamics, Springer, New York, 1998.

Remarks

The successful completion of the course implies achieving at least 55% of the total numer of points in both the course tests and final exam. All examination is done by using the written method.

<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">SOLID STATE PHYSICS I</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS</td><td>L+E</td></tr>
<tr><td>PCM5611</td><td>V</td><td>MANDATORY</td><td>6</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. Dr. Maja Đekić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">Course objective is to familiarize students with phenomena and physical laws of solid state matter.
Learning outcomes:
1. Understands basic laws in solid state
2. Independently solves problems from this field
3. Understands thermal properties of solid state</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">INTRODUCTION. Historic introduction into solid state physics. Crystalline and amorphous solids. Ideal crystal. Crystal lattice and base. Bravais lattice. Simple crystal structures. Miller indices. Reciprocal lattice. X-ray diffraction. Braggs law. Atomic scattering factor. Structure factor. TYPES OF BONDS IN CRYSTAL-ionic, covalent, metal, van der Walls. DEFECTS IN CRYSTAL-Real crystal. Classification of defects. Equilibrium concentration of Schottky and Frenkel defects. Deformations of solids. Dislocations. CRYSTAL LATTICE DYNAMICS- Harmonic approximation. Lattice vibrations of one-dimensional crystal. Chain of identical atoms. Chain of two types of atoms. Dispersion relation. Phonon. THERMAL PROPERTIES OF SOLIDS- specific heat of classical crystal-Dulon-Petit law. Quantum theory of specific heat- Einstein and Debye. Thermal expansion of solids. Thermal conductivity of solids. FREE ELECTRON MODEL IN METALS-Free electron gas in a box. Free electron gas statistics. Heat capacity of free electron gas. Thermoelectric emission. ELECTRICAL PROPERTIES OF SOLIDS-Electric conductivity-Ohm's law. Scattering of electrons. Thermal conductivity of metals. Hall effect. MODEL OF ENERGY ZONES IN SOLIDS- Introduction.</td></tr>
</table>

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

Literature

1. C.Kittel “Uvod u fiziku čvrstog stanja”Savremena administracija Beograd, 1970 godine
2. M. Pirić “Osnove kvantne mehanike, statističke fizike i fizike čvrstog stanja”, Univerzitetska knjga Sarajevo 2007. Godine.
3. V. Šips “Uvod u fiziku čvrstog stanja”, Školska knjiga Zagreb 1991. Godine

Remarks

Program	Level of studies	**First cycle**
	Program name	**Physics**
Course name	**INTRODUCTORY NUCLEAR PHYSICS**	

Course ID	Semester	Course status	ECTS credits	L+E
PHY5411	**V**	**MANDATORY**	**4**	**2+1**

Lecturer	**Prof. dr. Elvedin Hasović**
Aims and intended learning outcomes	The goal of the course is to introduce the phenomena and physical laws at the level of individual atoms and its nuclei. At the end of the course the student should be able to: - know the basic properties of nuclear forces; - know the basic properties of the nucleus; - apply the law of radioactive decay; - explain and analyze the occurrence of radioactive decay, fission and fusion; - solves numerical and conceptual problems in nuclear physics.

Course content

Nuclear properties. Dimension and shape of the nuclear core. Nuclear forces. Angular momentum and parity. Nuclear binding energy. Deuteron. Nucleon-Nucleon scattering. Nuclear models. Discovery of radioactivity. The law of radioactive decay. Radioactive series. Natural radioactivity. Alpha, beta and gamma decay. Artificial radioactivity. Nuclear reactions. Determination of age of a sample. Nuclear fission. Defect of mass. The process of nuclear energy release. Fission reactors. Nuclear fusion. Requirements for thermonuclear fusion. Fusion reactors. Interaction of radiation with matter.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	55	Course Test	50
Total	100	Final Exam	50
		Total	100

Literature

1. Lecture Notes.
2. N. Tanović, L. Tanović, *Fizika : osnove atomske i nuklearne fizike*, Sarajevo : Uniprint, 1991
3. S. Bikić, *Zbirka riješenih zadataka iz fizike*, Zenica : Dom štampe, 1998
4. L. Marinkov, Osnovi Nuklearne fizike, PMF Novi Sad, 2010.
5. R. A. Serway, C. J. Moses, C. A. Moyer, *Modern Physics*, Thomson Learning, 2005.
6. K. S. Krane, *Introductory nuclear physis*, John Wiley & Sons, 1985.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICS LABORATORY V**			
Course ID	Semester	Course status	ECTS	L+E
PHY5311	**IV**	**MANDATORY**	**2**	**0+2**
Lecturer	**Doc. Dr. Maja Đekić**			
Aims and intended learning outcomes	Course objective is to familiarize students through practical laboratory work with phenomena and physical laws at the atomic level. Learning outcomes: 1. Independently handles laboratory equipment and understands instructions from the manual 2. Independently assesses correctness of obtained results 3. Independently processes data			

Course content

1. Stefan-Boltzmann's law, 2. Determination of the electron charge to mass ration, 3. Millikan's experiment, 4. Electron difraction, 5. Microvawe interference, 6. Photoelectric effect, 7. Atomic spectra, 8. Radioactivity

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	10	Laboratory reports	40
Other	10	Test	24
Consultation	50	Final exam	36
Total		Total	100

Literature

1. M. Đekić i A. Salčinović Fetić: PRAKTIKUM IZ ATOMSKE FIZIKE, Prirodno-matematički fakultet, 2017,
2. url: http://www.pmf.unsa.ba/fizika/images/ udzbenici/praktikum_iz_atomske_fizike.pdf

Remarks

There is a possibility of adding new laboratory exercises. Students need to attend all laboratory exercises and have their laboratory reports graded by the Lecturer.

Program	Level of studies	**First cycle**
	Program name	**Physics**
Course name	**ADVANCED GENERAL PHYSICS LABORATORY**	

Course ID	Semester	Course status	ECTS credits	L+E
PHY5421	**V**	**MANDATORY**	**4**	**0+3**

Lecturer	**Doc. Dr. Amra Salčinović Fetić**
Aims and intended learning outcomes	Laboratory exercises are designed to enable to students to apply acquired knowledge from Physics courses. By working with experimental equipment using simple measurement instrumentation and parts, from optical to semiconductors components, students are introduced to a field of physics experiment design and construction. After completing the course student should have acquired enough skills and knowledge to design and construct simple Physics experiments.

Course content

List of laboratory exercises

1. Interference and diffraction of light:
   a) on single and double coil,
   b) on water waves
2. Measuring *g* using rotating liquid.
3. Measuring *g* using reversible pendulum.
4. Measuring Planck's constant using photoresistor.
5. Analysing current-voltage characteristics of a semiconductor photocell.
6. Analysing current-voltage characteristics of a LED
7. Electrical conductivity of a thin layers.
8. Magnetic characteristics of a graphite.
9. Mechanical black box.
10. Electrical black box.
11. Microwaves interference
12. Analysing magnetic properties of a liquid using laser light.
13. Light transmission through liquid crystal cell

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	35	Laboratory reports	60
Assignments	15	Final exam	40
Other	5		
Total	100	-	
		Total	100

Literature

Laboratory manual

Remarks

Every year six experimental exercises will be chosen from the above list. Students are obligated to complete all six exercises and to submit a laboratory report. Some exercises require a total of six hours to complete.

<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">QUANTUM MECHANICS II</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>PTH6711</td><td>VI</td><td>MANDATORY</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Dejan Milošević</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The objective of the course is to introduce students to the applications of quantum mechanics, as well as to enable them to independently solve the tasks from this fundamental field of theoretical physics. Formalism developed within the scope of the course Quantum Mechanics I will be applied to various problems of atomic and molecular physics, scattering theory, etc.
The learning outcome is mastering theoretical knowledge from the application of quantum mechanics and the ability to independently solve different problems from the application of quantum mechanics.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Approximative methods in quantum mechanics: stationary perturbation theory, variational method, quasiclassical (WKB) approximation, time-dependent perturbation theory. Semiclassical theory of radiation. Spin: Key experiments. Mathematical description of the spin. Pauli's equation. Quantum mechanics of many particle systems: Identical particles. Pauli's principle. Slater's determinant. Theory of atoms and molecules: Methods of calculation of atomic systems. Self-consistent field method (Hartree-Fock method). Thomas-Fermi method. The theory of molecules in adiabatic approximation. Scattering theory: Scattering cross section. Transition amplitude. Born approximation. Method of partial waves. Inelastic scattering.</td></tr>
</table>

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

<table>
<tr><td>Literature</td></tr>
<tr><td>Mandatory:
1. D. Milošević, Kvantna mehanika II, 2015 (available at e-learning)
Recommended:
1. L. I. Šif, Kvantna mehanika, Vuk Karadžić, Beograd, 1968.
2. Supek, Teorijska fizika i struktura materije, II dio, Školska knjiga, Zagreb, 1977.
3. W. Greiner, Quantum mechanics. An introduction, Springer, Berlin, 1989.</td></tr>
<tr><td>Remarks</td></tr>
<tr><td></td></tr>
</table>

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**STATISTICAL PHYSICS**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH6611	**VI**	**MANDATORY**	**6**	**3+2**
Lecturer	**Prof. dr. Aner Čerkić**			
Aims and intended learning outcomes	Aim of the course is to introduce students into statistical physics by lectures and exercises. Expected outcomes: Adopting the basic ideas and concepts of the equilibrium statistical physics. Mastering the mathematical apparatus of the classical and quantum statistical physics. Getting acquainted with the applications of the equilibrium statistical physics.			

Course content

Goal and methods of the statistical physics
Elements of the combinatorics and probability calculus.
Classical statistical physics
Microstates and macrostates of a system. Phase space and phase trajectories. Statistical ensemble. Distribution function. Liouville equation. Gibbs definition of entropy. Gibbs equilibrium ensembles. Applications of the canonical ensemble.
Quantum statistical physics
Mathematical apparatus of quantum mechanics. Density matrix. Gibbs equilibrium ensembles. Statistical sum of the ideal gas and solids. Mie-Grüneisen equation of state for solids.
Ideal gas of quantum-mechanical microobjects
Fermi-Dirac and Bose-Einstein statistics. Boltzmann distribution. Fully degenerate Fermi gas. Degenerate Fermi gas. Degenerate Bose gas – Bose-Einstein condensation. Weakly degenerate Bose gas. Weakly degenerate Fermi gas.
Application of quantum statistical physics
Photons. Phonons. Electron gas in metals.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	60		
Assignments	10		
Other	5	Midterm exam	50
Total	150	Final exam	50
		Total	100

Literature

Mandatory literature:
1. A. Čerkić, S. Odžak i D. Hadžiahmetović, *Statistička fizika*, Univerzitetsko izdanje, Sarajevo, 2013.

Additional literature:
1. Đ. Mušicki, *Uvod u teorijsku fiziku II - Statistička fizika*, Izdavačko informativni centar studenata (ICS), ŠIP Srbija, Beograd, 1975.
2. L. D. Landau, E. M. Lifšic, *Teoretičeskaja fizika. Tom V* (1): *Statističeskaja fizika*, Nauka, Moskva, 1976. (ruski, engleski, bosanski)
3. B. S. Milić, S. M. Milošević, Lj. S. Dobrosavljević, *Zbirka zadataka iz teorijske fizike*: *Statistička fizika*, Naučna knjiga, Beograd, 1979.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**SPECIAL THEORY OF RELATIVITY**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH6511	**VI**	**MANDATORY**	**5**	**2+2**
Lecturer	**Prof. dr. Elvedin Hasović**			
Aims and intended learning outcomes	The goal of the course is to provide students with basic knowledge about relativistic phenomena in mechanics, electrodynamics and optics. At the end of the course the student should be able to: -understand the basic principles of the theory of relativity; -apply the Lorentz transformations; -understand and apply the concept of the four-vector; - solve numerical problems in the field of theory of relativity.			

Course content

Introduction to the theory of relativity. Galilean transformations. Experimental foundations of special theory of relativity. Postulates of the special theory of relativity and their direct consequences. Lorentz transformations. Consequences of the Lorentz transformations. Length contraction and time dilation. The law of velocity addition. Relativistic Doppler effect. Interval and the proper time. Lagrange equations. Relativistic dynamics of the particle. Mass, energy, and momentum in theory of relativity. Invariance of physical laws in contrast to the Lorentz transformations. The concept of a four-vector. A four-vector formulation of the theory of relativity. Four-vector of position, velocity and momentum. Maxwell theory in relativistic form. Four-vector of current and potential. Equation of continuity. Electromagnetic Field Tensor. Maxwell equations.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	65	Course Test	50
Total	120	Final Exam	50
		Total	100

Literature

1. Lecture Notes.
2. N. Hasić, *Specijalna teorija relativiteta*, Svjetlost, Sarajevo, 1983
3. G. Knežević, *Zbirka zadataka iz specijalne teorije relativnosti*, Sarajevo : Prirodno-matematički fakultet, 2003
4. R. Resnick, *Introduction to Special Relativity*, John Wiley & Sons NY, 1968.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**SOLID STATE PHYSICS II**			
Course ID	Semester	Course status	ECTS	L+E
PCM6511	**VI**	**MANDATORY**	**5**	**2+2**
Lecturer	**Doc. Dr. Maja Đekić**			
Aims and intended learning outcomes	Aim of the course is to familiarize students with complicated problems and concepts in solid state physics and demonstrate how solid state physics explains some basic properties of materials: optical, transport, magnetic and thermodynamic properties. After they complete the course, students should be able to understand how the periodic crystal structure is reflected on the electronic structure of the solid and describe the electronic structure (ground state and excitation spectrum) of metals and insulators, relation between the electronic structure of the solid and their dielectric, magnetic and superconducting properties, use some several models to calculate the polarization, magnetization and superconductivity in the solid state.			

Course content

Metals: free electron model. Electrons in a periodic potential. Bloch's theorem. The Kronig-Penney model. Tight binding approximation. Weak binding approximation. Band gap and diffraction phenomena. Brillouin zone of one- and two-dimensional lattices. Brillouin zone of BCC and FCC lattices. Fermi surface and Brillouin zone. Extended, reduced and periodic zone schemes. Electron motion in a periodic field of a crystal – effective mass. Band filling – conduction and valence band in insulators, semiconductors and conductors. Transport properties of metals. Classical and quantum theory.
Semiconductors: intrinsic and extrinsic (doped). Fermi level in semiconductors, charge carrier density and mobility. Electron and hole densities in thermal equilibrium. Doping of semiconductors. Properties of p-n junction. Dielectric properties of matter. Deformation, electronic, ionic, orientation polarisability.
Magnetic properties of solids: diamagnetism, paramagnetism, ferromagnetism. Magnetisation curve – hysteresis. Magnetic properties of atoms. Temperature effect on magnetic properties. Magnetic anisotropy of crystals. Magnetostriction. Domain structure of ferromagnetic materials.
Superconductivity. Energy gap. Meissner effect. Theory of superconductivity. London equations. Type II superconductors. Josephson effect.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	35	Homework	10
Assignments	15	Midterm exam	50
Consultation	15	Final exam	40
Total	125	Total	100

Literature

1. M.Pirić: Osnove kvantne mehanike, statističke fizike i fizike čvrstog stanja, Univerzitetska knjiga, Sarajevo 2007.
2. Ch. Kittel: Uvod u fiziku čvrstog stanja, Savremena administracija, Beograd, 1970.
3. V. Knapp, P. Colić: Uvod u električna i magnetna svojstva materijala, Školska knjiga Zagreb, 1990.
4. H. Ibach, H. Lüth: Solid-State Physics An introduction to Principle of Material Science, Springer, 2009

Remarks

Midterm exam – 9^{th} week of classes

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

Course ID	Semester	Course status	ECTS credits	L+E
PHY6311	**VI**	**MANDATORY**	**3**	**2+0**

Lecturer	**Prof. dr. Mustafa Busuladžić**
Aims and intended learning outcomes	The goal of this course is to cover the history of natural science. Special attention is devoted to presentation of the development of the most important principles of the phyiscs from the deepest past to the present days in chronological order. At the end of the course the student should be able to understand how some of the essential concepts and laws of the physics developed in a historical context.

Course content

History of sciences in early cultures (5000-600 BC). Babylonia. Egypt. Phoenicia. India. China and Far East. Ionia and Early Greece. Greek mathematics. Greek astronomy. Greek physics and philosophy. The growth of experiment. Schools in ancient Greece. Thales. Anaximander. Pythagoras. Eudoxus. Aristotle. Anaxagoras. Empedocles. Democritus. Mathematics, physics and astronomy in Alexandria. Euclid. Archimedes. Hero of Alexandria. Diophantus. Aristarchus of Samos. Eratosthenes. Hipparchus. Ptolemy. Science in the Early Middle Ages. Al-Hazen. Al-Kwarizmi. Al- Biruni. Avicenna. Roger Bacon. Maricurt. Occam. Buridan. The mean speed therorem. Kinematics (Merton College, 14-th century).
The birth of modern science (15-th and 16-th century). Copernicus. Copernican heliocentrism. Brahe. Bruno. Mechanics, hydrostatics, optics, and magnetism. Stevinus. Del Monte. Tartaglia. Della Porta. Maurolico. Gilbert. The birth of a new physics (17-th century). Galilei. Kepler. Descartes. Leibniz. Huygens. Newton. Newton's law of motion and law of gravitation. Optics in the 17-th century.
Mechanics in the 18-th and 19-th century. The origins of analytic mechanics. Euler. J. Bernoulli. D'Alembert. Lagrange. Hamilton. Celestial mechanics. Laplace. Optics in the 18-th and 19-th century. Wave nature of light. Young. Fresnel. Atomic theory of matter. Avogadro's law. Energy and thermodynamics. Carnot. Mayer. Joule. Lord Kelvin. Helmholtz. Clausius. Boltzmann. Electricity. Franklin. Coulomb.The electric current. Galvani. Volta. Electrochemistry. Electromagnetism. Ørsted. Ampère. Ohm. Faraday. Lentz. Hertz. EM induction. Maxwell electrodynamics. EM waves.
The Michelson-Morley experiment. The Lorentz transformations. Einstein. The theory of relativity. Modern physics. Atomic and nuclear physics. X- radiation. Radioactivity. The electron. The structure of atom. Rutherford. Other particles. The quantum theory. Bohr. Planck. Heisenberg. The principle of uncertainty. De Broglie. Pauli. Schrödinger. Dirac. Fermi. Astrophysics. Other developments in modern physics.

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	20	Course Test	50
Total	50	Final Exam	50
		Total	100

Literature

1. Lecture Notes.
2. J. Jeans, The growth of physical science, reprint of first ed., Cambridge University Press, Cambridge, 2009.
3. Ž. Dadić, Povijest ideja i metoda u matematici i fizici, prvo izdanje, Školska knjiga, Zagreb, 1992.
4. Z. Faj, Pregled povijesti fizike, drugo izdanje, Sveučilište JJ Strossmayer, Osijek, 1999.
5. I. Supek, Povijest fizike, treće izdanje, Školska knjiga, Zagreb, 2004.
6. Muhamed Busuladžić, Historija fizike I, prvo izdanje, PMF, Sarajevo, 2008.

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.

IV YEAR

(VII i VII semester)

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**COMPUTATIONAL PHYSICS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PCS7611	**VII**	**MANDATORY**	**6**	**2+2**
Lecturer	**Prof. dr. Senad Odžak**			
Aims and intended learning outcomes	The aim of the course is to introduce students at a more advanced level into Computational physics through lectures and practical exercises. It is expected that students successfully adopt the content of the course and that the acquired knowledge is success fully applied in their further academic education and/or scientific work.			

Course content
Computers in physics. Information in physics. Operational systems. Programming in physics. Comparative studies of high level programming languages (Fortran, C and/or others).

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	70	Course Tests (Multiple assignments)	60
Assignments	0	Final Exam (Theory)	40
Other	5		
Total	150		
		Total	100

Literature

1. Lecture Notes
2. L. Nyhoff, L. Sanford, FORTRAN 77 for Engineers and Scientists with an Introduction to Fortran 90 (4th ed.), 1995.
3. Brian W. Kernighan, Denis M. Ritchie, Programski jezik C, Savremena administracija, Beograd, 1989.

Remarks

The successful completion of the course implies achieving at least 55% of the total numer of points in both the course tests and final exam. Course tests imply solving physical problems with computers. All examination is done by using the written method.

Program	Type of study (cycle)		**First cycle**	
	Name of the program		**Physics**	
Name of the course	**ELECTRONICS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP7511	**VII**	**MANDATORY**	**5**	**2+2**
Lecturer	**Prof. dr. Edvin Skaljo**			
Aims and intended learning outcomes	The goal and task of the course is to gradually introduce students with electronic elements and circles using lectures, laboratory exercises and practical work to prepare them for future work as a professor and / or researcher			

Course content

1. Linear electric circuit - overview
2. Ideal amplifiers
3. Semiconductor diodes
4. Bipolar transistor
5. Field effect transistors
6. Multiple amplifiers, energy electronics
7. Electronic circuits with feedback

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	50	Partial exams	40
Assignments	10	Practical work	15
Other	5	Student activity	5
Total	125	Final exam	40
		Total	100

Literature

1. „Osnovi elektronike“, Aljo Mujčić, Edin Mujčić, Nermin Suljnović, Tuzla 2015;
2. D. Milatović: Osnove elektronike, Svjetlost, Sarajevo 1995

Remarks

Program	Level of studies	**First cycle**
	Program name	**Physics**
Course name	**EXPERIMENTAL METHODS IN MODERN PHYSICS**	

Course ID	Semester	Course status	ECTS	L+E
PCM7211	**VII**	**MANDATORY**	**2**	**2+0**

Lecturer	**Doc.dr. Maja Đekić**
Aims and intended learning outcomes	Course objective is to familiarize students with experimental methods in modern physics. Learning outcomes: 1. Student is familiar with measuring techniques in physics 2. Student is familiar with diagnostic techniques in physics 3. Student is capable of choosing appropriate measuring and diagnostic techniques for concrete problem.

Course content

INTRODUCTION: Review and importance of experimental methods in modern physics. MICROSCOPY METHODS: Optical microscope and its limitations. Electron microscope. Historic introduction and parts of electron microscope. Types of electron microscope. Electron-sample interaction. SCANNING PROBE MICROSCOPY. Atomic force microscopy (AFM). Historic introduction and parts of AF microscope. AF microscope working principle. AFM advantages and disadvantages. SPECTROSCOPY. Importance of spectroscopy. Types of spectroscopy Spectroscope parts. Atomic and molecular spectroscopy. THERMAL ANALYSIS METHODS. Importance and types. Differential thermal analysis. Differential scanning calorimetry. Thermogravimetry. X-RAY METHODS. Generation of X-rays. X-ray diffraction. X-ray microscope. Computerized tomography. CRYOGENICS. Importance of low temperatures in physics. Discovery of superconductivity and superfluidity. Obtaining of low temperatures.

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	15	Test	20
Assignments	5	Paper	30
Other	5	Project	20
Total	50	Final exam	30
		Total	100

Literature

1. M. Furić “Moderne eksperimentalne metode, tehnike i mjerenja u fizici”, Školska knjiga Zagreb
2. S. Lukić-Petrović, F. Skuban, D. Petrović, G. Štrbac, I. Gut “Eksperimentalne tehnike karakterizacije materijala”

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**ADVANCED PHYSICS LABORATORY I**			
Course ID	Semester	Course status	ECTS	L+E
PCM7311	**VII**	**MANDATORY**	**3**	**0+3**
Lecturer	**Doc. Dr. Maja Đekić**			
Aims and intended learning outcomes	Aim of the course is the expansion of knowledge and concepts in modern physics and qualification of students for independent organization and execution of laboratory exercises under supervision. After successful completion of the course, students will be able to demonstrate and explain certain modern physics experiments, use a computer to interpret results, draw graphs and perform a statistical analysis of data.			

Course content
Study of crystal structures. The Franck-Hertz experiment. Thermionic emission. Certain physical properties of semiconductors. Thermoelectric phenomena in semiconductors. Nuclear magnetic resonance.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	15	Homework	30
Assignments	10	Midterm exam	30
Consultation	5	Final exam	40
Total	75	Total	100

Literature
1. Uputstva za vježbe iz Višeg fizikalnog praktikuma I, nerecenzirana interna skript 2. Ch. Kittel: Uvod u fiziku čvrstog stanja, Savremena administracija, Beograd, 1970.
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">COMPUTATIONAL PHYSICS II</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>PCS8611</td><td>VIII</td><td>MANDATORY</td><td>6</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Senad Odžak</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of the course is to introduce students to basic numerical methods with application in the field of Theoretical Physics and the ability to use computers in the modeling of physical systems and processes. It is expected that students successfully adopt the content of the course and that the acquired knowledge is successfully applied in further academic education and/or scientific work.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Numericaly solving of transcendental equations. Interpolation. Numerical differentiation. Numerical integration. Numerical aspects of differential equations. Differential equations of higher order. Numerov method. Methods of linear algebra. Recursive and iterative algorithms.</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>70</td><td>Course Tests
(Multiple assignments)</td><td>60</td></tr>
<tr><td>Assignments</td><td>0</td><td>Final Exam (Theory)</td><td>40</td></tr>
<tr><td>Other</td><td>5</td><td></td><td></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. Lecture Notes
2. R. H. Landau, M. J. Páez Mejiá, Computational Physics, Problem Solving with Computers, John Wiley & Sons, 1997.
3. Paul L. de Vries, A First Course in Computational Physics, John Wiley & Sons, New York 1993
4. M. Hjorth-Jensen, Computational Physics, University of Oslo, 2007.

Remarks

The successful completion of the course implies achieving at least 55% of the total numer of points in both the course tests and final exam. Course tests imply solving physical problems with computers. All examination is done by using the written method.

Program	Type of study (cycle)		**First cycle**	
	Name of the program		**Physics**	
Name of the course	**ELECTRONICS II**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP8611	**VIII**		**6**	**2+2**
Lecturer	**Prof. dr. Edvin Škaljo**			
Aims and intended learning outcomes	The goal and task of the course is to introduce students to advanced electronic elements and schemes using lectures, laboratory exercises and practical work to prepare them for future work as a professor and / or researcher.			

Course content
Number systems and Boolean algebra; logic gates and their applications; memory elements; counters, registers and readout systems; multivibrators, A/D and D/A converters; optolectronics: Internet of Things;

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	50	Partial exams	40
Assignments	10	Practical work	15
Other	5	Student activity	5
Total	125	Final exam	40
		Total	100

Literature
1. „Osnovi elektronike“, Aljo Mujčić, Edin Mujčić, Nermin Suljnović, Tuzla 2015; 2. D. Milatović: Osnove elektronike, Svjetlost, Sarajevo 1995

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">DEVELOPMENT OF MODERN THEORETICAL 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>PTH8311</td><td>VIII</td><td>MANDATORY</td><td>3</td><td>2+0</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 provide students with basic knowledge in the areas of theoretical physics that developed in the second half of the twentieth century, such as particle physics, astrophysics and cosmology.

At the end of the course the student should be able to:

-know the classification of elemental particles;
-understand the mechanism of creating bound states of elementary particles;
-recognize and understand the basic stages in the life cycle of the stars;</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">A brief history of the development of particle physics, astrophysics and cosmology. Photon, mezons, antiparticles, neutrino, strange particles, fundamental forces in nature. The quark model, Standard model of elementary particles. Weak interactions, decay of particles and conservation laws. Symmetries and conservation laws. Violation of the CP symmetry, TCP theorem. Modern experiments in elementary particle physics. The principle of equivalence and the general theory of relativity, experimental confirmation of the general theory of relativity. Sources of energy in stars, nucleosynthesis, energy transport in stars. White dwarfs, neutron stars, black holes. Expansion of the Universe, Hubble's Law, Big Bang Theory, Cosmic Background Radiation.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	45	Course Test	50
Total	75	Final Exam	50
		Total	100

Literature

1. Lecture Notes.
2. F. Close, *Svemirska lukovica : kvarkovi i priroda svemira*, Zagreb : Školska knjiga, 1997.
3. K. Krane, *Modern Physics* 2nd ed., John Wiley and Sons, NY, 1996.
4. W. Carroll, D. A. Ostlie, *An Introduction to Modern Astrophysics* 2nd ed. , Benjamin Cummings, Upper Saddle River, NJ, 2006.
5. D. J. Griffiths, *Introduction to Elementary Particles*, John Willey and Sons, NY, 1987.

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">ADVANCED PHYSICS LABORATORY 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>PCM8311</td><td>VIII</td><td>MANDATORY</td><td>3</td><td>0+3</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. Dr. Maja Đekić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">Aim of the course is the further expansion of knowledge and concepts in modern physics and qualification of students for independent organization and execution of laboratory exercises under supervision.
After successful completion of the course, students will be able to demonstrate and explain certain modern physics experiments, use a computer to interpret results, draw graphs and perform a statistical analysis of data, organize a laboratory exercise and adopt rules of safe laboratory practices and procedures.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Atomic spectra. Magnetic susceptibility of solids and liquids. Hall effect in metals. Measurement of dielectric permittivity of ice. Photoelectric effect.</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>45</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>15</td><td>Homework</td><td>30</td></tr>
<tr><td>Assignments</td><td>10</td><td>Midterm exam</td><td>30</td></tr>
<tr><td>Consultation</td><td>5</td><td>Final exam</td><td>40</td></tr>
<tr><td>Total</td><td>75</td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">1. Uputstva za vježbe iz Višeg fizikalnog praktikuma II, nerecenzirana interna skripta
2. Ch. Kittel: Uvod u fiziku čvrstog stanja, Savremena administracija, Beograd, 1970.
3. H. Ibach, H. Lüth: Solid-State Physics An introduction to Principle of Material Science, Springer, 2009</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

POSSIBLE ELECTIVE COURSES IN FIRST YEAR

Program	Level of studies	**First cycle**
	Program name	**Physics**

Course name	**INTRODUCTION TO COMPUTER SCIENCE FOR PHYSICISTS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PCS1311	**I**	**ELECTIVE**	**3**	**3**
Lecturer	**Prof. dr. Senad Odžak**			
Aims and intended learning outcomes	The aim of the course is to gradually introduce students into the practical use of computers through the mastery of basic of MS Office programs. Students are expected to successfully adopt the content of the course, pass the exam and be able to use the specified programs.			

Course content

1. Introduction: Internet and e-mail.
2. Introduction to MS Office.
3. MS Word – Creating, opening and saving documents.
4. MS Word – Entering and editing text.
5. MS Word – Formatting text, paragraphs and headings. Setting up the document.
6. MS Word – Themes and templates. Spelling and grammar tools.
7. MS Word – Printing word documents. Planing with Outlines.
8. Midterm exam
9. MS Excel – Creating and navigating worksheets.
10. MS Excel – Adding information to worksheets. Moving data around a worksheet.
11. MS Excel – Managing worksheets and workbooks.
12. MS Excel – Formatting cells. Viewing and printing worksheets.
13. MS Excel – Building basic formulas.
14. MS Excel – Tables and graphics.
15. MS Excel – Numerical integration of tabular data in Excel.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	20	Midterm exam	50
Assignments	0	Final exam	50
Other	10		
Total	75		
		Total	100

Literature

1. Lecture notes
2. C. Grover, M. MacDonald, E. A. V. Vander Veer, Office 2007: The missing manual, 2008.
3. J. Preppernau, J. Lambert, C.Frye, Microsoft Office Professional 2010 Step by step, 2010

Remarks

Study program	Level of the study program		**First cycle**	
	Name of the study program		**Physics**	
Course name	**COMMUNICATION SKILLS FOR PHYSICISTS**			
Course ID	Semester	Course status	ECTS credits	L+E
PED1311	**I**	**ELECTIVE**	**3**	**2+1**
Lecturer	**Prof. dr. Vanes Mešić**			
Aims and intended learning outcomes	The aim of this course is to develop the students' skills of scientific communication. Intended learning outcomes: 1. Describe the nature of scientific knowledge and inquiry. 2. Make effective oral presentations. 3. Produce written materials of high quality.			

Course content

The concept of communication.
The nature of scientific knowledge and inquiry. Communicating scientific ideas.
Basics of scientific writing – part I (Analysing the audience. Identifying sources of relevant literature).
Basics of scientific writing – part II (Analysing relevant literature. Developing an outline).
Basic of scientific writing – part III (Writing different sections of a scientific text. Citing references).
Effective presentation skills – part I (Contents of the presentation. Structure of the presentation).
Effective presentation skills – part II (Visual aids).
Effective presentation skills – part III (Delivery of the presentation).
Writing e-mails. Writing business letters. Writing job application letters.
Popularization of science in the mass media.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	10	Oral presentation	30
Assignments	15	Seminar paper	30
Other	5	Partial exam	20
Total	75	Final exam	20
		Total	100

Literature

1. Čengić, M. (2005). Vještina pisanja. Sarajevo: DES.
2. Alley, M. (2013). The Craft of Scientific Presentations. New York: Springer.
3. Alley, M. (2018). The Craft of Scientific Writing. New York: Springer.
4. Lannon, J. M, & Gurak, L.J. (2017). Technical Communication. Boston: Pearson.

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">INTRODUCTION TO COMPUTER SCIENCE FOR PHYSICISTS II</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>PCS2211</td><td>II</td><td>ELECTIVE</td><td>2</td><td>0+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Senad Odžak</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The objective of the course is to introduce students to perform various calculations in the Mathematica software package. 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Introduction to Mathematica package. Manipulations with numbers. Manipulations with symbolic expressions. Logical terms and their use. Solving equations, inequalities, and systems. Manipulations with lists, vectors and matrices. Function graphs. Examples in physics. Introduction to procedural programming. Basic numerical calculations. Export and import of data. Examples in physics.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	15	Course Test	50
Assignments	0	Final Exam	50
Other	5		
Total	50		
		Total	100

Literature

1. Lecture Notes
2. Ž. Jurić, Interaktivna računanja u programskom paketu Mathematica, skripta, PMF, Sarajevo, 2006.
3. S. Wolfram, The Mathematica Book, Cambridge University Press, Cambridge, 2003.

Remarks

The successful completion of the course implies achieving at least 55% of the total number of points in both the partial and final exam.

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**ENGLISH LANGUAGE**			
Course ID	Semester	Course status	ECTS	L+E
POT2211	**I**	**ELECTIVE**	**2**	**2+0**
Lecturer				
Aims and intended learning outcomes	The aim of English language teaching is to provide students with active language skills in order to be able to communicate with their counterparts abroad; to be enabled to use professional literature to track the development of their profession and, thanks to their knowledge of languages, to participate in the world events at all. After completing the module, students will: - To acquire active knowledge of English; - Being trained to communicate with colleagues from abroad; - Be trained to track professional literature; - Being trained to track global events in the world.			

Course content

English language system. Significance and distinction of minimum pairs. Pronunciation exercise. English alphabet. Spelling exercise. Present the verb "to be". Personal pronouns. Noun. Single and multiples. Numerous and non-numeric nouns. Certain and indefinite. Typical phrases. Indicative pronouns. Numbers. Constructions "there is ...", "there are ...". Expressing Static Spatial Relationships. Negation. Difference "Some-any-no". Imperative. Keep up to date. Creation and use, Adjectives: Types and Comparison. Participle in adjective use. Incorrect comparison. Pronouns. Names of days and months. Create new words. Derivation. Word families. Measurement and measuring units. Ordinary present. Difference in use between simple and continuous present. Past and proper time for irregular verbs. Modal verbs: present and past times. Future. Ways of expressing the future. Revision of verb tenses. Adverbs typical of certain times. Perfect times. General characteristics of word creation. Present perfect. Past perfect. Differences in the use of past times. Passive: creation and use. Conditional sentences: Type I, II and III. Impersonal verb forms. Infinitive. Past and present participle. Gerund. Dependent compound sentences: types and typical conjunctions. Ability to compress. Direct and indirect speech. Sequence. Structure of the text: chronological and logical relations. Conjunctions.

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	20	Midterm exam	50
Total	50	Final exam	50
		Total	100

Literature

1. H. F. Brookes, H. Ross: “English as a foreign language for science students”, Heinmann Educational Books, London (I i II dio)

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**LASER PHYSICS FUNDAMENTALS**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH6411	**VI**	**ELECTIVE**	**4**	**2+1**
Lecturer	**Prof. dr. Dejan Milošević**			
Aims and intended learning outcomes	The aim of the course is to introduce students to basic concepts of the laser physics. The learning outcome is mastering knowledge from the basics of laser physics.			

Course content

Interaction of laser radiation with matter. Creation of inverse population. Optical resonators. Continuous and non-stationary laser modes. Types of lasers. Laser applications.

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

Literature

Mandatory:

1. D. Milošević, Osnove lasera (sa zbirkom riješenih zadataka), 1996. (available at e-learning)

Recommended:

1. V. Henč-Bartolić, L. Bistričić, Predavanja i auditorne vježbe iz fizike lasera, Element, Zagreb, 2001.
2. D. Milatović, Optoelektronika, Svjetlost, Sarajevo, 1987.
3. N. Konjević, Uvod u kvantnu elektroniku, laseri, Naučna knjiga, Beograd, 1981.
4. S. Lugomer, M. Stipančić, Laser – fizikalne osnove, konstrukcija i primjene, Svjetlost, Sarajevo, 1977.
5. W. T. Silfvast, Laser Fundamentals, Cambridge University Press, Cambridge, 1996.

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">FUNDAMENTALS OF CHAOS 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>PTH6421</td><td>VI</td><td>ELECTIVE</td><td>4</td><td>2+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 basic ideas of the deterministic chaos theory. Expected outcomes: Adopting the basic ideas and concepts of the deterministic chaos theory. Mastering the mathematical apparatus of the deterministic chaos theory. Getting acquainted with the applications of the deterministic chaos theory to real physical systems.</td></tr>
</table>

Course content

Qualitative dynamics

Vector fields as dynamical systems

Some definitions of vector fields and their integral curves. Equilibrium positions and linearization of vector fields. Stability of equilibrium positions. Critical points of Hamiltonian vector fields. Stability and instability of the free top.

Long-term behaviour of dynamical flows and dependence on external parameters

Flows in phase space. More general criteria for stability. Attractors. The Poincare mapping. Bifurcations of flows at critical points. Bifurcation of periodic orbits.

Deterministic chaos

Iterative mappings in one dimension. Qualitative definitions of deterministic chaos. An example: The logistic equation.

Quantitative measures of deterministic chaos

Routes to chaos. Liapunov characteristic exponents. Strange attractors.

Chaotic motions in celestial mechanics

Rotational dynamics of planetary satellites. Orbital dynamics of asteroids with chaotic behavior.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	40		
Assignments	10		
Other	5	Midterm exam	50
Total	100	Final exam	50
		Total	100

Literature

Mandatory literature:
1. F. Scheck, *Mechanics - From Newton's Laws to Deterministic Chaos*, Springer-Verlag, Berlin, 2005.

Additional literature:
1. S. Nettel, *Wave physics. Oscillations – Solitons – Chaos*, Springer, Berlin, 1997.
2. P. Davies (editor), *The New Physics*, University Press, Cambridge, 1989.
3. H. J. Korsch, H.-J. Jodl, *Chaos. A program collection for the PC*, Springer, Berlin, drugo izdanje, 1998.
4. M. R. Belić, *Deterministički haos*, Sveske fizičkih nauka, III (3), Beograd, 1990.

Remarks

Program	Level of studies		First cycle	
	Program name		Physics	
Course name	ADVANCED COURSE OF OPTICS			
Course ID	Semester	Course status	ECTS credits	L+E
PTH6431	**VI**	**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.
Nonmonochromatic 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 Wave Front 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. Kirchhoffs Approximation. Fraunhofer Diffraction. Fresnel Diffraction.
Propagation of Light in Anisotropic Media. Birefringence. Polarization in birefringence. Polaroid. Polychroism. 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 studente must score at least 22 points, and the total score must be at least 55 points.

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Type of study (cycle)</td><td colspan="2">First cycle</td></tr>
<tr><td colspan="2">Name of the program</td><td colspan="2">Physics</td></tr>
<tr><td>Name of the course</td><td colspan="4">ELECTRICAL MEASUREMENTS OF NON-ELECTRIC QUANTITIES</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>PCM6411</td><td>Sixth (VI)</td><td>ELECTIVE</td><td>4</td><td>2+1</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Edvin Škaljo</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The objective of the course is for students to acquire the skills of converting non-electrical quantities into electrical quantities in order to process the information received, transfer it to the desired destination and use or store it.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Analogy of mechanical and electrical systems and quantities. Sensors. Measurement of temperature, pressure and speed, and conversion of measured values into electrical quantities. Measuring and converting other sizes such as humidity, density, concentration of desired and unwanted ingredients. Introduction to basic settings for transmitting information from sensors in the form of an electrical or optical signal, and an introduction to the transmission of information over the Internet.</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>Partial exams</td><td>40</td></tr>
<tr><td>Assignments</td><td>10</td><td>Seminar</td><td>20</td></tr>
<tr><td>Other</td><td>5</td><td>Student activity</td><td>10</td></tr>
<tr><td>Total</td><td>125</td><td>Final exam</td><td>30</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. Senzori i merenja / Mladen Popović 316696
2. Fizičko-tehnička merenja: merenje neelektričnih veličina električnim putem / Dragan Stanković 1975557
3. Osnove automatike. Dio 1, Mjerenja neelektričnih veličina / Florijan Rajić 152834</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

<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">ATOMIC AND MOLECULAR 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>PTH7511</td><td>VII</td><td>ELECTIVE</td><td>5</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 the ideas and mathematical apparatus of atomic and molecular physics. Expected outcomes: Getting acquainted with experimental and theoretical basics of atomic and molecular physics. Mastering the mathematical apparatus of atomic and molecular physics. Getting acquainted with practical applications of atomic and molecular physics.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Lifting of the orbital degeneracy in the spectra of alkali atoms. Orbital and spin magnetism, fine structure. Atoms in a magnetic field: Experiments and their semi-classical description. Atoms in a magnetic field: Quantum mechanical treatment. Atoms in an electric field. General laws of optical transitions. Many-electron atoms. X-ray spectra, internal shells. Structure of the Periodic System, ground states of the elements. Nuclear spin, hyperfine structure. The laser. Modern methods of optical spectroscopy. Progress in quantum physics: A deeper understanding and new applications. Fundamentals of the quantum theory of chemical bonding.</td></tr>
</table>

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

<table>
<tr><td>Literature</td></tr>
<tr><td>Mandatory literature:
1. H. Haken, H. C. Wolf, The Physics of atoms and Quanta - Introduction to Experiments and Theory, Springer-Verlag, Berlin, 2005.

Additional literature:
1. M. Terzić, M. Kurepa, Uvod u fiziku atoma i molekula, Univerzitet u Novom Sadu, Prirodno-matematički fakultet, Studentski trg, Beograd, 1997.
2. P. W. Atkins, R. S. Friedman, Molecular quantum mechanics, Oxford University Press, Oxford, 2005.
3. B. V. Stanić, M. I. Marković, Zbirka rešenih zadataka iz atomske fizike, Nauka, Beograd, 1995.
4. K. Bartschat, Computational atomic physics, Springer-Verlag, Berlin, 1996.</td></tr>
<tr><td>Remarks</td></tr>
<tr><td></td></tr>
</table>

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**QUANTUM FIELD THEORY I**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH7521	**VII**	**ELECTIVE**	**5**	**2+2**
Lecturer	**Prof. dr. Dejan Milošević**			
Aims and intended learning outcomes	The aim of the course is to introduce students to concepts and the mathematical apparatus of quantum field theory. After studying relativistic quantum mechanics, the basics of classical field theory and nonrelativistic quantum field theory will be presented. The learning outcome is mastering the basic concepts and the mathematical apparatus of classical and quantum field theory.			

Course content

Klein-Gordon equation. Dirac equation and symmetry transformation. Solution of the Dirac equation for a free particle. Dirac equation and interaction. Classical field theory. Theorem Noeter. Nonrelativistic quantum field theory.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	60	Partial exam	50
Assignments		Final exam	50
Other			
Total	125		
		Total	100

Literature

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

Recommended:
1. W. Greiner, J. Reinhardt, Field quantization, Springer, Berlin, 1996.
2. N. Zovko, Osnove relativističke kvantne fizike, Školska knjiga, Zagreb, 1987.
3. I. Supek, Teorijska fizika i struktura materije, II dio, Školska knjiga, Zagreb, 1977.

Remarks

Program	Level of studies		**First cycle studies**	
	Program name		**Physics**	
Course name	**MATHEMATICAL METHODS OF PHYSICS III**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH7411	**VII**	**ELECTIVE**	**4**	**2+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 finite group theory. Mastering the mathematical apparatus of the group theory. Getting acquainted with discrete group symmetries and with their applications in physics.			

Course content

Group definition. Cayley table. Subgroup. Normal subgroup. Factor group. Conjugacy classes. Group representation. Dihedral group. Isomorphism and homomorphism. Similarity transformation. Direct sum. Direct product. Projection operator. Schur's lemma. Characters of representation. Young tableaux.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	40		
Assignments	10		
Other	5	Midterm exam	50
Total	100	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	Type (cycle)		**First cycle**	
	Module		**Physics**	
Course title	**ELEMENTARY PARTICLE PHYSICS I**			
Code	Semestar	Status	ECTS	L+E
PTH8621	**VIII**	**ELECTIVE**	**6**	**2+2**
Lecturer	**Doc. dr. Admir Greljo**			
Aims and intended learning outcomes	The goal of the course is to introduce the main subject and mathematical formalism of theoretical elementary particle physics. The expected outcome is to enable students to explore advanced topics as well as follow modern trends in this area of physics.			

Course contents

Classification of elementary particles. A short review of mathematical formalism for scalar, spinor, and vector particles. Abelian gauge theories. Feynman diagrams. Cross sections and decay rates. Non-abelian gauge theories. Spontaneous symmetry breaking. Goldstone theorem. Higgs mechanism and the Standard Model.

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 Modern Introduction to Quantum Field Theory / Maggiore
2. 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

Other

Program	Level of studies		**First cycle studies**	
	Program name		**Physics**	
Course name	**QUANTUM FIELD THEORY II**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH8611	**VIII**	**ELECTIVE**	**6**	**2+2**
Lecturer	**Prof. dr. Dejan Milošević**			
Aims and expected learning outcomes	The aim of the course is to deepen students' knowledge of quantum field theory through different examples and applications. Developed formalism of quantum field theory will be applied to quantum electrodynamics and students will be introduced to selected fields of higher course of quantum field theory. Learning outcomes are mastering the applications of quantum field theory and quantum electrodynamics.			

Course content

Fields with spin 0: Klein-Gordon equation. Fields with spin 1/2: Dirac equation. Fields with Spin 1: Maxwell and Proca equations. Quantization of the photon field. Quantum fields with interactions. Quantum electrodynamics. Selected problems of advanced quantum field theory.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	90	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. W. Greiner, J. Reinhardt, Field quantization, Springer, Berlin, 1996.
2. N. Zovko, Osnove relativističke kvantne fizike, Školska knjiga, Zagreb, 1987.
3. I. Supek, Teorijska fizika i struktura materije, II dio, Školska knjiga, Zagreb, 1977.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICS OF METALS I**			
Course ID	Semester	Course status	ECTS	L+E
PCM7511	**VII**	**ELECTIVE**	**5**	**2+2**
Lecturer	**Doc. Dr. Amra Salčinović Fetić**			
Aims and intended learning outcomes	Aim of this course is the introduction with processes of forming, types and properties of pure metals and metallic systems, introduction to physical processes which control and dominate the forming of solid phases as well as the experimental methods for investigation of certain metallic properties. After the completion of this course students will be expected to have acquired a general knowledge concerning properties of metals and metallic systems, rules of formation of different solid phases during solidification, the process of solid phase growth out of melts, as well as their properties. Students should be able to understand the experimental techniques which enable the examination of physical properties of metals, their structures and phase transition points, and master some practical skills concerning sample preparation and metallographic analysis.			

Course content

Basics about metals. Properties of metallic elements and their position in the periodic table. Crystal structure of metals. Real crystals. Defects and their influence on metallic properties. Experimental methods for metal investigation. Microscopic methods. X-ray methods. Mechanical tests. Methods for determination of phase transition points.
Thermodynamics of phase transitions. Equilibrium. Gibbs free energy as a function of temperature for single-component systems. Solidification. Homogeneous nucleation. Homogeneous nucleation rate. Heterogeneous nucleation. Crystal growth. Continuous and lateral growth. Metallic alloys. Mechanical alloying. Types of solid solutions, rules of their formation. Substitutional solid solutions. Hume-Rothery rules. Interstitial solid solutions. Hägg's rules. Solid solutions. Solid solutions based on defects. Intermetallic compounds and superstructures. Binary alloy structure. Concept of phase. Gibbs' phase rule. Mutual solubility of metals. Solubility representation using phase diagrams. Rules for phase diagrams interpretation. Example of a simple phase diagram reading: components soluble in liquid state and insoluble in solid state.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	30	Homework	10
Assignments	20	Seminar paper	10
Consultation	15	Midterm exam	40
Total	125	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. 5. D. A. Porter, K. E. Easterling: Phase transformations in metals and Alloys, Chapman&Hall 1984.

Remarks

Laboratory exercises: 1. Metallographic microscope, 2. Mechanical processing of samples for microscopic investigation, 3. Chemical etching of the sample surface, 4.Electrolytic polishing of samples, 5. Quantitative examination under a metallographic microscope, 6. Quantitative examination of complex systems
Midterm exam – 9th week of lectures

<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 SEMICONDUCTORS I</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS</td><td>L+E</td></tr>
<tr><td>PCM7521</td><td>VII</td><td>ELECTIVE</td><td>5</td><td>2+1</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. Dr. Maja Đekić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">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</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">INTRODUCTION. Significance of semiconductors. Structure of semiconducting crystals. Bravais lattice . Miller indices. Energy zones in semiconductors. Electrons and holes. Effective mass. Ideal and real semiconductors. Energy spectrum of carriers in real semiconductors. Doping. Elementary theory of doping states. Defects in semiconductors. Intrinsic semiconductors. Extrinsic semiconductors. Statistics of electrons and holes in semiconductors. Density of states. Fermi level. Transport properties. Boltzmann kinetic equation. Relaxation time. Electric conductivity. Hall effect. Thermal conductivity. Thermoelectric effects. Thermomagnetic effects. Magnetoresistance.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	50	Assessment method	Points
Exam preparation	50	Laboratory exercises	45
Assignments	30	Paper	15
Other		Test	20
Total	125	Final exam	20
		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		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICS OF THIN FILMS**			
Course ID	Semester	Course status	ECTS	L+E
PCM7411	**VII**	**MANDATORY**	**4**	**2+0**
Lecturer	**Doc. Dr. Maja Đekić**			
Aims and intended learning outcomes	Course objective is to familiarize students with production methods and properties of thin films. Learning outcomes: 1. Understands methods of thin films production 2. Understands physical properties of thin films 3. Understands different possibilities for thin film applications.			

Course content

INTRODUCTION. Significance of semiconductors. Structure of semiconducting crystals. Bravais lattice . Miller indices. Energy zones in semiconductors. Electrons and holes. Effective mass. Ideal and real semiconductors. Energy spectrum of carriers in real semiconductors. Doping. Elementary theory of doping states. Defects in semiconductors. Intrinsic semiconductors. Extrinsic semiconductors. Statistics of electrons and holes in semiconductors. Density of states. Fermi level. Transport properties. Boltzmann kinetic equation. Relaxation time. Electric conductivity. Hall effect. Thermal conductivity. Thermoelectric effects. Thermomagnetic effects. Magnetoresistance.

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

Literature

1. T. M. Nenadović i T. M. Pavlović: Fizika i tehnika tankih slojeva, Institut za nuklearne nauke Vinča Univerziteta u Nišu, 1997.
2. M. Ohring: Materials science of thin films, AP, San Diego, 1995.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICS OF METALS II**			
Course ID	Semester	Course status	ECTS	L+E
PCM8611	**VIII**	**ELECTIVE**	**6**	**2+2**
Lecturer	**Doc. Dr. Amra Salčinović Fetić**			
Aims and intended learning outcomes	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.			

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 the semester

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

Program	Level of studies		First cycle	
	Program name		Physics	
Course name	PHYSICS OF IONIZING RADIATION I			
Course ID	Semester	Course status	ECTS credits	L+E
PAP7521	**VII**	**ELECTIVE**	**5**	**2+2**
Lecturer	**Doc. dr. Benjamin Fetić**			
Aims and intended learning outcomes	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 process 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.			

Course content

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 equilibrrium compound decay, transient equilibrrium 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.

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 student must score at least 22 points, and the total score must be at least 55 points.

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**MEDICAL RADIATION PHYSICS I**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP7531	**VII**	**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 monoenrgetic 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		**First cycle**	
	Program name		**Physics**	
Course name	**RADIOLOGICAL PROTECTION**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP7411	**VII**	**ELECTIVE**	**6**	**2+2**
Lecturer	**Doc. dr. Adnan Beganović**			
Aims and intended learning outcomes	Objective: To give students detailed theoretical and practical knowledge of radiological protection. Outcomes: master and understand modern methods and techniques of radiological protection used in medicine and other activities and apply them in everyday practice			

Course content

1. Basics of Ionizing Radiation Physics: Sources of ionizing radiation; Physical quantities and units in radiation protection; Basic principles of detection and measurement of ionizing radiation; Dosimetry calculations and measurements; Exercises
2. Basics of Radiation Biology: The effects of ionizing radiation at molecular and cellular levels; Deterministic effects; Somatic stochastic effects; Hereditary stochastic effects; Influence on embryo and foetus; Epidemiological studies; Radiation risk; Basics of biodosimetry; Exercises
3. Basic principles of radiation protection: Radiation protection system; Basic principles of protection: justification, optimization and dose limitation; The role of international organizations in radiation protection; Safety culture.
4. Legal regulations: The legal system in radiation protection and the safe use of sources of ionizing radiation in Bosnia and Herzegovina and the world;
5. Radiation Protection in professional exposure: Methods of protection and safe use of sources of ionizing radiation; Optimization principle; Individual monitoring and monitoring of work space; Health surveillance; Potential exposure to ionizing radiation; Estimation of external and internal exposure to ionizing radiation sources; Occupational exposure to ionizing radiation in medicine, industry and scientific research
7. Medical exposure to ionizing radiation: Justification of medical exposure to ionizing radiation; Optimization of medical exposure protection; Accidental exposure to ionizing radiation in medical applications
8. Emergency Events: General principles and types of possible events; Basic concept of procedures and preparation for nuclear or radiological accidents; Assessment and procedures in case of radiological hazards; Medical care of injuries caused by accidental exposure to ionizing radiation; Public relations; International co-operation.

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.
5. IAEA. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. Vienna, Austria: IAEA; 2014.

Remarks

Exercises are performed at the Clinical Centre of Sarajevo University.

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**PHYSICS OF IONIZING RADIATION II**			
Course ID	Semester	Course status	ECTS credits	L+E
PAP8621	**VIII**	**ELECTIVE**	**6**	**2+2**
Lecturer	**Prof. dr. Azra Gazibegović - Busuladžić**			
Aims and intended learning outcomes	The aim of this course is to give students basic knowledge of the process of ionizing radiation interaction with matter and the detection of ionizing radiation. After completing the course, students should understand the basics of the processes that occur in the interaction of ionizing radiation with matter and solve related problems. Student should understand the principles of the detection of ionizing radiation.			

Course content

Interaction of photons with matter: Linear attenuation coefficient and exponential attenuation. HVL. Mass, electron and atomic attenuation coefficients. Transfer and absorption of energy. Energy transfer and energy absorption coefficient. Coherent and incoherent scattering. Photoelectric effect. Dependance on atomic number and photon energy. Thomson (classic) scattering. Rayleigh (coherent) scattering. Compton (incoherent) scattering. The probability of Compoton collisions (Klein-Nishina coefficient). Production of electron-positron pairs. Energy distribution of electrons and positrons formed in the pair production. Total attenuation coefficient. Total energy transfer and energy absorption coefficient. Multiple processes, Monte Carlo simulations.

Interaction of charged particles with matter: Interaction of heavy charged particles with matter. Stopping power. Bragg peak. The interaction of the electron with matter. Energy loss by radiation. Mean stopping power. Linear Energy Transfer (LET). Monte Carlo simulations.
Rang (range) of particles, its dependence on energy, charge, mass. Brag - Kleeman's rule.
General properties and principles of ionizing radiation detectors operation. Gas detectors. Liquid detectors. Solid-state detectors. Spectrometers of ionizing radiation.
Passage of neutrons through matter.

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	65	Midterm exams	40
Assignments	25	Seminar	20
Total	150	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 studente must score at least 22 points, and the total score must be at least 55 points.

<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">MEDICAL RADIATION PHYSICS II</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>PAP8631</td><td>VIII</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: 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">1. Instruments and techniques for measuring ionizing radiation in human radiology: Ionization chamber; Geiger-Müller counter; Solid state detectors; Thermoluminescent dosimetry (TLD); Chemical dosimeters; Film dosimeters; Calorimeters; Counting statistics; Exercises.
2. Radiotherapy I: Biological basis of radiotherapy; Fractionation; Dose modification factor; Biological and physical models for optimization; Radiotherapy process; Determination of the absorbed dose at the reference point; Dose distribution by depth; Dose variation depending on SSD, field size and energy; Electronic beams; Dose gradient; Dosimetry protocols; Calibration of radiotherapy devices; External radiotherapy and brachytherapy; QA and protection against radiation in therapy; Exercises.
3. Radiotherapy II: Radiotherapy planning; Algorithm for the calculation of the dose distribution; The role of CT scanners and CT simulators in the planning process; Planning system; Optimization of treatment; Wedge filters, compensators, protection blocks and patient immobilisation devices; Basics of 2D and 3D planning; Special treatment techniques; TBI; Stereotaxy; IMRT; VMAT; Exercises.
4. Nuclear medicine: Radiopharmacology; Production of radionuclides; Generators; Localization mechanisms; Radioimmunoassays; Detectors and collimators in Nuclear Medicine; Scanners; Creating an image of individual parts of the body and organs using radioactive sources; Gamma camera; SPECT and PET; Radioactive tracers; Biological and effective time of half-life; Introduction to the MIRD model; Biokinetics of Radioactive Substances; QC in Nuclear Medicine; Exercises.
5. Diagnostic Radiology: Introduction; Primary radiographic image; Radiographic image; Characteristics and quality of the radiographic image; Radiographic film; Television techniques; Optimizing the device for creating a radiographic image; Tomography and stereo-diagnostics; Digital radiography; DSA; Mammography; CT device; Quality assurance in diagnostic radiology; Measurement and assessment of patients dose; Radiation risk in diagnostic radiology; Exercises
6. Radiation Protection: Equivalent and effective dose; Background radiation; Protective barriers; Protection in institutions that use ionizing radiation sources; Committed effective dose and collective dose; ICRP principles; Workplace monitoring; Waste management and transportation of nuclear and radioactive materials; Exercises.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	60	Assessment method	Points
Exam preparation	75	Midterm	45
Other	15	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		**First cycle**	
	Program name		**Physics**	
Course name	**GENERAL PSYCHOLOGY**			
Course ID	Semester	Course status	ECTS	L+E
POT4411	**VI**	**ELECTIVE**	**4**	**2+1**
Lecturer	**Prof. Dr. Dženana Husremović**			
Aims and intended learning outcomes	The aim of the module is to get acquainted with the basics of psychology, with special emphasis on the psychology of adolescents, personality psychology, pedagogical psychology and the elements of social psychology. Through the curriculum of this module, and in particular through the various forms of teaching, teaching methods, teaching principles, teaching organization, future teachers will have the opportunity to better understand the student's personality and prepare for a good transfer of knowledge to the students. Upon completion of this module, the student will be able to work independently in the school and other institutions working with students as well as for independent research work using the knowledge gained from the methodology of research in psychology.			
Course content				
- Introduction to Psychology as a Doctrine. Psychology of Adolescents. Periodization of adolescent psychological development. Characteristics of development in early, middle and late adolescence. - Introduction to Personality Psychology. Personality and understanding of personality. Personality Structure. Personality Dynamics. Development personality. - Introduction to Pedagogical Psychology. Learning and memory. Types of learning. Learning theories. Memory and forgetting. Learning transfer. Factors of successful learning. - Introduction to Social Psychology. Observing other people. Social attitudes. - Group behavior. Structure of the group. Psychology of the group. Group leadership. Group standards.				

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	45	Midterm exam	30
Assignments	10	Homework	20
Consultation	100	Final exam	50
Total		Total	100

Literature

1. B. Stevanović: "Pedagoška psihologija"
2. Smiljanić-Čelanović: "Dečja psihologija", Beograd, 1967
3. N. Tot: "Psihologija ličnosti", Beograd, 1963
4. L. Žlebnik: "Psihologija deteta i mladjih", III, Beograd, 1972

Remarks

Study program	Level of the study program	**First cycle**
	Name of the study program	**Physics**
Course name	**PHYSICS EDUCATION I**	

Course ID	Semester	Course status	ECTS credits	L+E
PED5611	**VII**	**ELECTIVE**	**6**	**4+2**

Lecturer	**Prof. dr. Vanes Mešić**
Aims and intended learning outcomes	The aim of this course is to develop in students understanding about learning and teaching physics, as well as the attitudes and values that are important for the physics teacher profession. Intended learning outcomes: 1. Analyse the cycle of scientific inquiry and explains the concept of physical model. 2. Discuss the aim of learning physics at different educational levels and describe the most important features of physics curricula. 3. Apply the fundamental ideas of cognitive psychology in discussing various aspects of physics teaching and interpret the most important didactic principles. 4. Describe the implementation of selected teaching moves, methods and formats, and analyse various assessment techniques. 5. Compare the didactic potentials of various educational technologies and describe the strategies of implementing experiments and solving problems in physics classrooms. 6. Describe the strategies of planning for physics teaching.

Course content

Didactics and methodics.
Quality of education. Trends in education at the local and international level.
Knowledge of physics: contents and processes. Evolution of physics. Physics and other disciplines.
Nature of physics. Cycle of scientific inquiry. Methods of scientific inquiry in physical sciences.
The aim of learning physics. The curriculum concept. Features of a physics curriculum. School-family-community partnership.
The psychological foundations of learning and teaching physics. Didactic principles.
Language of physics. Development of physics concepts. Preconceptions and misconceptions.
Teaching moves, methods and formats.
Educational technologies. Facilitating learning through experiments. Facilitating learning through solving problems.
Assessing learning outcomes in physics classes.
Planning and evaluation of physics teaching.
Action research.

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Points
Exam preparation	45	Classroom activities	20
Assignments	10	Seminar paper	15
Other	5	Partial exam	25
Total	150	Final exam	40
		Total	100

Literature

1. Muratović, H., Mešić, V. (2009). *Didaktičko-metodički prilozi nastavi fizike*. Sarajevo: Prirodno-matematički fakultet.
2. Mešić, V. (2015). *Uvod u didaktiku fizike*. Sarajevo: Prirodno-matematički fakultet.
3. Bransford, J., Brown, A. L., Cocking, R.R. (2000). *How People Learn: Brain, Mind, Experience, and School*. Washington: NAP.

Remarks

<table>
<tr><td rowspan="2">Study program</td><td colspan="2">Level of the study program</td><td colspan="2">First 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">LABORATORY IN PHYSICS EDUCATION 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>PED5411</td><td>VII</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 safety 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 basic principles of cognitive psychology.
5. Identify, evaluate and design hands-on experiments in physics.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Introducing the students with the syllabus.
Basic measurements in mechanics.
Kinematics.
Dynamics.
Gravitational field. Free fall.
Stability. Static equilibrium. Decomposition and superposition forces.
Pressure.
Statics of fluids.
Energy, work and power. Friction.
Simple machines.
Particulate nature of matter. Heat phenomena – part I.
Heat phenomena – part II.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	25	Partial exam	40
Assignments	25	Project	10
Other	5	Final exam	50
Total	100		
		Total	100

Literature

1. Vrcelj, A. (n.d.). *Metodički praktikum – mehanika i termodinamika* (interna skripta). Sarajevo: Prirodno-matematički fakultet.
2. Physics textbooks for the primary and secondary school level.
3. Cunningham, J., & Herr, N. (1994). *Hands-on physics activities with real-life applications: easy-to-use labs and demonstrations for grades 8-12* (Vol. 3). Jossey-Bass.

Remarks

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

Program	Level of studies		**First cycle**	
	Program name		**Physics**	
Course name	**GENERAL PEDAGOGY**			
Course ID	Semester	Course status	ECTS	L+E
POT3411	**VII**	**ELECTIVE**	**4**	**2+1**
Lecturer	**Prof. dr. Hasnija Nurković**			
Aims and intended learning outcomes	The objective of the module is to get acquainted with pedagogical theory and practice. Through the teaching units of this module, and in particular through various forms of teaching, teaching methods, teaching principles, teaching organization, teacher training, future teachers will have the opportunity to prepare for the best quality transfer of knowledge to students. Upon completion of this module, the student will be able to work independently in the school and other institutions in which pedagogical practice is performed, as well as for independent research work using the accepted knowledge from the methodology of pedagogical research.			

Course content

- The subject of pedagogy and basic pedagogical concepts (education, self-seeking, education, self-education, refusal). Pedagogical discipline system.
- Relationship between pedagogy and other sciences. The development and characteristics of the pedagogical thought of the 20th century.
- Methodology of Pedagogical Research; Development of personality; Objective and Tasks of Education; Structure and characteristics
education system in our country;
- Family: role of family in education; styles of family education; behavioral disorders and modern families; family co-operation in school.
- Free time: importance and role in youth development.
- Humanization of the relationship: the concept of humanization and the possibility of developing human relations in the family and school.

Psychological and Pedagogical Aspects of Human Sexuality; the need and importance of the sexual education of young people.

The purpose and tasks of adult education and training. Didactics with elements of pedagogical psychology;

- Learning process and learning process: techniques and methods of successful learning; forming work habits; learning motivation; samples of formalism in student's knowledge; promotion of teaching and innovation; grading.

Programming of school work.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	45	Midterm exam	30
Assignments	10	Homework	20
Consultation	100	Final exam	50
Total		Total	100

Literature

1. P. Šimlesa: Pedagogija, Zagreb (više izdanja)
2. N. Potkonjak, J. Đorđević: Pedagogija, Beograd
3. B. Stevanović: Pedagoška psihologija

Remarks

Study program	Level of the study program	**First cycle**
	Name of the study program	**Physics**
Course name	**PHYSICS EDUCATION II**	

Course ID	Semester	Course status	ECTS credits	L+E
PED6611	**VIII**	**ELECTIVE**	**6**	**4+2**

Lecturer	**Prof. dr. Vanes Mešić**
Aims and intended learning outcomes	The aim of this course is to develop the students' knowledge, skills, attitudes and values that are important for the physics teacher profession. Intended learning outcomes: 1. Identify and describe the educational law and bylaws in Canton Sarajevo, and demonstrate the ability to conduct the corresponding administrative tasks. 2. Evaluate physics curricula and textbooks, and locate various resources that potentially facilitate planning and implementation of physics classes. 3. Perform didactic reconstruction of a given physics concept through use of various methods/technologies, and develop a lesson plan based on the 5E model. 4. Describe the different aspects of physics homework and develop a test for a given physics topic. 5. Develop a monthly and annual work plan, as well as a lesson plan. 6. Demonstrate mastery of physics topics that are part of primary and secondary school curricula, and conduct/analyse physics lessons.

Course content

Structure of the educational system in Bosnia and Herzegovina. Educational laws and bylaws.
Role of physics at different educational levels. Curricula in Canton Sarajevo.
Physics textbooks at local and international level. Physics teaching resources.
Didactic reconstruction.
Deductive and inductive teaching methods. 5E model
Developing multimedial presentations.
Assessing students' learning outcomes in physics. Test construction. Physics homework.
Macro and micro lesson planning in physics education.
Evaluating the quality of physics education.
Conduction and analysis of physics lessons.

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Points
Exam preparation	45	Portfolio	20
Assignments	10	Partial exam	40
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. Mešić, V. (2015). *Uvod u didaktiku fizike*. Sarajevo: Prirodno-matematički fakultet.
3. Mattes, W. (2007). *Nastavne metode: 75 kompaktnih pregleda za nastavnike i učenike*. *Zagreb: Naklada Ljevak*.

Remarks

Study program	Level of the study program		**First cycle**	
	Name of the study program		**Physics**	
Course name	**LABORATORY IN PHYSICS EDUCATION II**			
Course ID	Semester	Course status	ECTS credits	L+E
PED6311	**VIII**	**ELECTIVE**	**3**	**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. 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 safety 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.			

Course content

Introducing the students with the syllabus.
Electrostatics – part I.
Electrostatics – part II.
Direct current – part I.
Direct current – part II.
Magnetic field.
Electromagnetic induction.
Electric motor. Generator.
Oscillations and waves.
Ray optics – part I.
Ray optics – pat II.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	15	Partial exam	40
Assignments	10	Project	10
Other	5	Final exam	50
Total	75		
		Total	100

Literature

1. Vrcelj, A. (n.d.). *Metodički praktikum – elektromagnetizam i optika* (interna skripta). Sarajevo: Prirodno-matematički fakultet.
2. Physics textbooks for primary and secondary school.

žSprott, 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.

<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">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">DIDACTICS</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS</td><td>L+E</td></tr>
<tr><td>PED8412</td><td>VIII</td><td>MANDATORY</td><td>4</td><td>2+1</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. Dr. Hasnija Nurković</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to explore fundamental problems related to didactic theory and educational practice.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">- Didactics within the taxonomy of scientific disciplines.
- Historical development of didactics.
- The instructional process.
- Didactic systems
- Learning and teaching
- Teaching methods
- Educational technologies
- Communication and interaction in the classroom
- Evaluation of instruction
- Methodology of educational research
- The epistemological aspect of instruction
- The psychological aspect of instruction
- Implementing a lesson
- Organizing a lesson
- Preparing a lesson</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>45</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>45</td><td>Presence and activity</td><td>20</td></tr>
<tr><td>Assignments</td><td>10</td><td>First partial exam</td><td>30</td></tr>
<tr><td></td><td></td><td>Final exam</td><td>50</td></tr>
<tr><td>Total</td><td>100</td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">1. Poljak,V. (1978). Didaktika. Zagreb: Školska knjiga.
2. Matijević, M, Bognar,L. (2002) Didaktika. Zagreb: Školska knjiga.
3. Nurković,H, Lukaš, M. (2016). Aspekti razrednog menadžmenta. Sarajevo: PMF.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
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