UNIVERSITY OF SARAJEVO

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

STUDY PROGRAM
PHYSICS EDUCATION

CONCEPTUALLY INTEGRATED FIRST AND SECOND CYCLE

UNIVERSITY OF SARAJEVO

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

CURRICULUM FOR THE ACADEMIC YEAR 2019/2020

PHYSICS EDUCATION

FIRST CYCLE

GENERAL INFORMATION ABOUT THE STUDY PROGRAM

NAME OF THE STUDY PROGRAM:	Physics Education
TYPE OF THE STUDY PROGRAM:	University Study Program
LEVEL OF THE STUDY PROGRAM:	First Cycle of Higher Education
GOALS OF THE STUDY PROGRAM:	• To acquire fundamental knowledge and skills in the fields of general and modern physics, as well as in the field of physics education, • To develop conceptual understanding of physics, as well as the ability to solve problems in general physics, • To develop abilities and skills of using experimental and mathematical methods, as well as computers in physics, • To train prospective physics teachers in effective planning of the educational process, • To train prospective physics teachers in effective identifying and using of various teaching methods and technologies, • To develop in students the awareness of the importance of iteratively improving their own teaching practice, • To develop communicational, social, mathematical, informatics and research skills.
PROVIDER OF THE STUDY PROGRAM:	University of Sarajevo, Faculty of Science, Department of Physics
SCIENTIFIC AREA OF THE STUDY PROGRAM:	Physics (subfield: Physics Education)
STRUCTURE OF THE STUDY PROGRAM:	The classes are delivered in the form of lectures, seminars, recitations, labs/practices. After second year of study, besides physical science courses students also enrol in educational science courses. Elective courses are offered in the 1st, 2nd, 7th and 8th semester. A total of 52 ECTS credits are allocated to educational science courses and 11 ECTS credits to elective courses.
DURATION OF THE STUDY PROGRAM:	The study program lasts for 4 years (8 semesters).
LANGUAGE OF THE STUDY PROGRAM:	Bosnian/Croatian/Serbian/ English if needed
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 Education“. 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 Education 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 Education degree qualifies the holder to teach physics in primary schools and vocational secondary schools. The diploma holder is also qualified to work as laboratory technician in primary schools, secondary schools and faculties. Furthermore, she/he is also qualified to work as teaching assistant at faculties, as well as at other institutions that employ bachelors of science in physics education.
ACCESS TO FURHER STUDY:	The holder of the Bachelor of Science in Physics Education degree is eligible to apply for admission to the 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 Education is based on students' evaluation of teachers and teaching assistants, as well as the evaluation of each individual course. Evaluation is carried out after each semester, and students have the opportunity to express their opinions on the course contents, students' workload in the course, the quality of teaching and the organization of exams. Obtained results are analyzed and reports are delivered to teachers for each course individually. Based on course evaluation feedback, teachers are expected to continuously improve the quality of their courses.
INTENDED LEARNING OUTCOMES AT THE LEVEL OF THE STUDY PROGRAM:	**Learning outcomes in the field of Physics** The diploma holder is able to: ● Formulate and solve 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 analyse experimental data and communicate the results, ● Describe fundamental principles of modern physics and solve simple, typical problems within the formalism of modern physics, ● Use mathematics and computers for purposes of modelling simple physical phenomena. **Learning outcomes in the field of Physics Teaching** The diploma holder is able to: ● Use efficiently the specifications provided in primary/secondary school curricula when planning physics classes, ● Evaluate critically the didactic potentials of various sources of information and teaching resources in general when planning physics classes, ● Combine different teaching methods and resources with the aim of ensuring the interactivity of physics classes, ● Use experimental and mathematical methods of

	physics as well as computers for purposes of fulfilling the learning objectives, ● Use different assessment techniques, and to align them with instruction and learning objectives, ● Implement simple physics projects in classes, ● Do simple action research. **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 Physics Laboratory – Advanced Course I — 3 ECTS Physics Laboratory – Advanced Course II — 3 ECTS Laboratory in Physics Education I — 4 ECTS Laboratory in Physics Education II — 3 ECTS Laboratory in Physics Education III — 4 ECTS Laboratory in Physics Education IV — 4 ECTS Physics Teaching Practice I — 5 ECTS Physics Teaching Practice II — 5 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 MANDATORY AND ELECTIVE COURSES

FIRST AND SECOND YEAR

COURSES	SEMESTERS				
	I	II	III	IV	(E)CTS CREDITS
	P+V	P + V	P+V	P + V	
Mechanics	3+3				7
Physical Measurements I	3+2				6
Linear algebra for physicists	3+3				7
Mathematical Analysis for physicists I	3+3				7
Elective course					3
Total ECTS credits					**30**
Oscillations, waves and fundamentals of thermodynamics		3+3			7
Physical Measurements II		2+1			5
Mathematical Analysis for physicists II		3+4			8
Physics laboratory I		0+3			4
General chemistry for physicists		2+1			4
Elective course					2
Total ECTS credits					**30**
Electromagnetism			3+2		6
Classical mechanics I for teachers			3+2		6
Mathematical methods of physics I for teachers			3+3		7
Physics Laboratory II			0+2		3
Physics Laboratory III			0+3		4
Pedagogy			2+1		4
Total ECTS credits					**30**
Optics				3+2	6
Introduction to atomic physics				2+2	5
Classical mechanics II for teachers				3+2	6
Mathematical methods of physics II for teachers				3+3	7
Physics Laboratory IV				0+2	2
Educational Psychology				2+1	4
Total ECTS credits					**30**

THIRD AND FOURTH YEAR

COURSES	SEMESTERS				
	V	VI	VII	VIII	(E)CTS CREDITS
	P+V	P + V	P+V	P + V	
Introductory nuclear physics	**2+1**				**4**
Quantum mechanics I	**3+2**				**7**
Physics Laboratory V	**0+2**				**3**
Theory of Electromagnetic Field	**2+2**				**6**
Physics education I	**4+2**				**6**
Laboratory in physics education I	**0+3**				**4**
Total ECTS credits					**30**
Quantum mechanics II		**3+2**			**7**
Statistical physics		**3+2**			**6**
Special theory of relativity		**2+2**			**5**
Physics education II		**4+2**			**6**
Laboratory in physics education II		**0+3**			**3**
History of physics		**2+0**			**3**
Total ECTS credits					**30**
Computational Physics I			**2+2**		**6**
Advanced Physics Laboratory I			**0+3**		**3**
Laboratory in physics education III			**0+3**		**4**
Physics teaching practice I			**3+2**		**5**
Solid state physics I			**2+2**		**6**
Inclusion in physics education			**2+1**		**3**
Elective course					**3**
Total ECTS credits					**30**
Computational Physics II				**2+2**	**6**
Advanced Physics Laboratory II				**0+3**	**3**
Laboratory in physics education IV				**0+3**	**4**
Physics teaching practice II				**3+2**	**5**
Solid state physics II				**2+2**	**5**
Didactics				**2+1**	**4**
Elective course					**3**
Total ECTS credits					**30**

FIRST YEAR

(I AND II SEMESTER)

<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">MECHANICS</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>PHY1711</td><td>I</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 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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.</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. 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

<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">PHYSICAL MEASUREMENTS 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>PHY1611</td><td>I</td><td>MANDATORY</td><td>6</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. dr. Amra Salčinović Fetić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">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</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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.</td></tr>
</table>

<table>
<tr><td colspan="2">Student workload (hours)</td><td colspan="2">Grading</td></tr>
<tr><td>Lectures and Exercises</td><td>75</td><td>Assessment method</td><td>Points</td></tr>
<tr><td>Exam preparation</td><td>75</td><td></td><td></td></tr>
<tr><td>Assignments</td><td></td><td>Midterm exam</td><td>50</td></tr>
<tr><td>Consultation</td><td>150</td><td>Final exam</td><td>50</td></tr>
<tr><td>Total</td><td></td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">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</td></tr>
<tr><td colspan="4">Remarks</td></tr>
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<tr><td>Program</td><td colspan="2">Level of studies</td><td colspan="2">First cycle</td></tr>
<tr><td></td><td colspan="2">Program name</td><td colspan="2">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">LINEAR ALGEBRA FOR PHYSICISTS</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>POT1711</td><td>I</td><td>MANDATORY</td><td>7</td><td>3+3</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 aim of the course is that students learn mathematical operations with vectors and matrices, and with linear operators in general.

It is expected that the student is able to perform operations with vectors and matrices, and to describe their various applications (solving linear equations, transformations, etc.);
The student is able to describe properties of Euclidean space, curves and surfaces of the second order.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Vectors in the two and three-dimensional space. The scalar product of vectors and applications. Vector (cross) product and applications. 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.</td></tr>
</table>

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

<table>
<tr><td>Literature</td></tr>
<tr><td>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.</td></tr>
<tr><td>Remarks</td></tr>
<tr><td></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">Educational physics</td></tr>
<tr><td>Course name</td><td colspan="4">MATHEMATICAL ANALYSIS FOR PHYSICISTS 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>POT1721</td><td>I</td><td>MANDATORY</td><td>7</td><td>3+3</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">Aim of the course is to develop the ability to deal with differential calculus.
The students will be able to:
-apply calculus in physics problems.
-use various convergence tests.
- describe the behaviour of differentiable functions.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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</td></tr>
</table>

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">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICAL MEASUREMENTS 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>PHY2511</td><td>II</td><td>MANDATORY</td><td>5</td><td>2+1</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. dr. Amra Salčinović Fetić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">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 will understand the work principle of electrical measurements devices, and know how to use them properly as well as to independently estimate and evaluate the necessary calculations in the planning of the experiment.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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.</td></tr>
</table>

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

Program	Level of studies		**First cycle**	
	Program name		**Educational physics**	
Course name	**MATHEMATICAL ANALYSIS FOR PHYSICISTS II**			
Course ID	Semester	Course status	ECTS	L+E
POT2811	**II**	**MANDATORY**	**8**	**3+4**
Lecturer	**Prof. dr. Nacima Memić**			
Aims and intended learning outcomes	The aim of the course is to develop the ability to calculate and use integrals in various applications. Students are expected to: -apply the notions of integrals in physics problems -deal with various techniques for calculating integrals - use integration in physics problems			

Course content

1. Integration table - Integration methods
2. Integration of rational and trigonometric functions
3. Integration of irrational functions- Binomial integral
4. Definite integral - Riemann sum
5. Riemann integrability criterion
6. First mean value theorem for integrals
7. fundamental theorem of calculus
8. Change of variables in definite 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

Student workload (hours)		Grading	
		Assessment method	Points
Lectures and Exercises	90	Midterm exam	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

<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">PHYSICS LABORATORY 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>PHY2411</td><td>II</td><td>MANDATORY</td><td>4</td><td>0+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 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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.</td></tr>
</table>

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
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	**Educational 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

Program	Level of studies		**First cycle**	
	Program name		**Educational 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 examinations are done by using the written method.

Program	Level of studies	**First cycle**
	Program name	**Educational Physics**
Course name	**CLASSICAL MECHANICS I FOR TEACHERS**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH3621	**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 interpret an effective potential graph. The student will be familiar with dynamic laws for systems of particles and characteristic physical quantities, and methods for solving problems of dynamics of particle systems with constraints. The student will be 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.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	75	Midterm exams	55
Total	150	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	**Educational Physics**
Course name	**MATHEMATICAL METHODS OF PHYSICS I FOR TEACHERS**	

Course ID	Semester	Course status	ECTS credits	L+E
PCS3711	**III**	**MANDATORY**	**7**	**3+3**

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 and forced linear harmonic motion, etc), the variation of a constant method.

Student workload (hours)		Grading	
Lectures and Exercises	90	Assessment method	Points
Exam preparation	70	Midterm exam	50
Assignments	10	Final exam	50
Other	5		
Total	175		
		Total	100

Literature

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

Remarks

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

Course ID	Semester	Course status	ECTS credits	L+E
PHY3311	**III**	**MANDATORY**	**3**	**0+2**

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 thermodynamics. Students are expected to: 1. gain self-confidence in handling laboratory equipment 2. learn the basic methods of physical quantities measurements in the field of thermodynamics 3. collect acceptable data by measuring, analyze them, interpret the obtained results and draw the appropriate conclusions

Course content
Surface tension Thermal expansion of solids Gas processes Basic calorimetric measurements Specific heat capacity of metals and gases Phase transitions Thermal conductivity Determination of the convective heat transfer coefficient

Student workload (hours)		Grading	
Lectures and Exercises	30	Assessment method	Points
Exam preparation	30	Laboratory reports	40
Assignments	10	Test	20
Other	5	Final practical exam	40
Total	75		
		Total	100

Literature

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.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Educational 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 the 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 a 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. Electric motor 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

Program	Level of studies	**First cycle**
	Program name	**Educational physics**
Course name	**PEDAGOGY**	

Course ID	Semester	Course status	ECTS	L+E
POT3412	**III**	**MANDATORY**	**4**	**2+1**

Lecturer	**Prof. Dr. Hasnija Nurković**
Aims and intended learning outcomes	The aim of this course is that students acquire basic knowledge about pedagogy and become able to articulate their pedagogical thoughts in a scientific manner.

Course content

The pedagogical science: role in the system of scientific disciplines, basic pedagogical teachings and theoretical concepts.
Bloom's taxonomy of educational objectives in the cognitive and affective domain.
Anthropological views of education and systems of values.
Competencies and authority of a successful teacher.
Teacher authority and classroom management.
Communication as a phenomenon of constructing mutual understanding.
Therapeutic-empathic communication by Thomas Gordon.
First exam
Interactive communication aspect of school leadership
Humans' openness for awareness (pedagogical optimism and pedagogical pessimism).
Fundamental areas of an individual's development.
Relevant approaches to moral development (Kohlberg's model).
Pedagogical processes within cultural processes.
Interdisciplinarity and scientific autonomy.
Second exam

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

Literature

1. Ćatić,R, Stevanović, M. (2003). Pedagogija. Zenica: PF.
2. Nurković,H, Lukaš, M. (2016). Aspekti razrednog menadžmenta. Sarajevo: PMF.
3. Ćatić, R. (2006). Elementi savremene pedagogije. Zenica: PF.

Remarks

Program	Level of studies	**First cycle**
	Program name	**Educational Physics**
Course name	**OPTICS**	

Course ID	Semester	Course status	ECTS credits	L+E
PHY4611	**IV**	**MANDATORY**	**6**	**3+2**

Lecturer	**Prof. dr. Mustafa Busuladžić**
Aims and intended learning outcomes	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.

Course content

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.

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

<table>
<tr><td rowspan="2">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">INTRODUCTION TO ATOMIC 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>PHY4611</td><td>IV</td><td>MANDATORY</td><td>5</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 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</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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 the 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 BOHR'S MODEL. Wilson-Sommerfeld quantization rules. Elliptical model. Space quantization. QUANTUM MECHANICAL ATOMIC MODEL. Matter waves-de Broglie wavelength. Davisson-Germer experiment. Heisenberg uncertainty principle. WAVE FUNCTION 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.</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>65</td><td>Test</td><td>50</td></tr>
<tr><td>Assignments</td><td></td><td>Final exam</td><td>50</td></tr>
<tr><td>Other</td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td>125</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. N.Tanović i L.Tanović: OSNOVE ATOMSKE I NUKLEARNE FIZIKE, Uniprint Sarajevo, 1991.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Program	Level of studies		**First cycle**	
	Program name		**Educational Physics**	
Course name	**CLASSICAL MECHANICS II FOR TEACHERS**			
Course ID	Semester	Course status	ECTS credits	L+E
PTH4611	**IV**	**MANDATORY**	**6**	**3+2**
Nosilac programa	**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. - apply 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 dynamics. 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 bracket. Canonical transformations, Hamilton-Jacobi equation. Symmetries and conservation laws. E. Noether 's theorem.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	75	Midterm exam	55
Total	150	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		**Educational Physics**	
Course name	**MATHEMATICAL METHODS OF PHYSICS II FOR TEACHERS**			
Course ID	Semester	Course status	ECTS credits	L+E
PCS4711	**IV**	**MANDATORY**	**7**	**3+3**
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, a student will be able to use complex analysis in solving physical problems; use Fourier series and Fourier transformation in physical problems; 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.			

Course content

Complex algebra; complex functions; Cauchy-Riemann conditions; line integral; Cauchy's integral theorem; Cauchy's integral formula and its 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 lemma. Dispersion relations. Euler's functions (Beta and Gamma). Fourier transformation and uncertainty principle. Dirac delta function; Sine and cosine transformations. Convolution theorem. 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 for PDE. 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. Schrodinger equation for hydrogen 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.

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. 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, Mathematical methods for physics and engineering, 3rd edition, Cambridge University Press
2. G. Arfken, H. Weber, Mathematical 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.

<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">PHYSICS LABORATORY IV</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PHY4211</td><td>IV</td><td>MANDATORY</td><td>2</td><td>0+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 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 behaviour of the light to conduct experiments;
-collect and appropriately analyze data working independently and in collaboration with other students.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Spherical mirrors.
Converging and diverging lenses.
Optical instruments.
Spectrometry.
Photometry.
Interference. Young double-slit experiment. Newton rings.
Fraunhofer diffraction at a single slit.
Plane diffraction grating.
Polarization.
He-Ne laser.</td></tr>
</table>

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 tests as well as an 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.

<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">EDUCATIONAL PSYCHOLOGY</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS</td><td>L+E</td></tr>
<tr><td>POT4412</td><td>IV</td><td>MANDATORY</td><td>4</td><td>2+2</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">Introducing the students with the research subject of educational psychology, its methods and research techniques. Students are expected to acquire knowledge about learning theories and their classroom applications. They will be able to describe the importance of the teacher-student interaction for a successful instruction. They will be able to plan and implement various approaches for motivating the students and for preventing student misbehaviour in the classroom. Students are also expected to acquire knowledge about students with special needs and to develop skills needed for effective assessment of students' outcomes. Generally, students are expected to be able to apply the acquired knowledge and skills in the classroom.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Introduction to educational psychology. Research methods and techniques in educational psychology. The learning process and memory. Phenomena which accompany learning. Factors that affect memory and learning. Individual differences in learning. Motivation. First exam. Classroom management. Students' misbehaviour. Partnership with students' parents. Students with special needs. Gifted students. Classroom assessment. Second exam.</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>Partial exams</td><td>30</td></tr>
<tr><td>Consultation</td><td>100</td><td>Final exam</td><td>50</td></tr>
<tr><td>Total</td><td></td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">Andrilović, V. & Čudina-Obradović, M. (1996). Psihologija učenja i nastave, IV dopunjeno izdanje. Zagreb: Školska knjiga.
Grgin, T. (1997). Edukacijska psihologija. Naklada Slap.
Vizek, V.V., Rijavec, M., Vlahović-Štetić, V. & Miljković, D. (2003). Psihologija obrazovanja. Zagreb: IEP.
Andrilović, V. (1991). Metode i tehnike istraživanja u psihologiji odgoja i obrazovanja. Zagreb: Školska knjiga.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

THIRD YEAR (V AND VI SEMESTER)

Program	Level of studies		**First cycle**	
	Program name		**Educational physics**	
Course name	**INTRODUCTORY NUCLEAR PHYSICS**			
Course ID	Semester	Course status	ECTS	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; - solve 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 physics, John Wiley & Sons, 1985.

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">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">QUANTUM MECHANICS 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>PTH5711</td><td>V</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 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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.</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

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

<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">PHYSICAL LABORATORY V</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS</td><td>L+E</td></tr>
<tr><td>PHY5311</td><td>IV</td><td>MANDATORY</td><td>2</td><td>0+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 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</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">1. Stefan-Boltzmann's law, 2. Determination of the electron charge to mass ratio, 3. Millikan's experiment, 4. Electron diffraction, 5. Microwave interference, 6. Photoelectric effect, 7. Atomic spectra, 8. Radioactivity</td></tr>
</table>

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

Program	Level of studies	**First cycle**
	Program name	**Educational Physics**
Course name	**THEORY OF ELECTROMAGNETIC FIELD**	

Course ID	Semester	Course status	ECTS credits	L+E
PTH5611	**V**	**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 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.

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

Course ID	Semester	Course status	ECTS credits	L+E
PED5611	**V**	**MANDATORY**	**6**	**4+2**

Lecturer	**Prof. dr. Vanes Mešić**

Aims and intended learning outcomes	The aim of this course is to develop 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 explain the concept of the 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>Level of the study program</td><td colspan="2">First cycle</td></tr>
<tr><td>Name of the study program</td><td colspan="2">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="3">LABORATORY IN PHYSICS EDUCATION I</td></tr>
</table>

<table>
<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>V</td><td>MANDATORY</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>
</table>

Course content

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.

<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>25</td><td>Partial exam</td><td>40</td></tr>
<tr><td>Assignments</td><td>25</td><td>Project</td><td>10</td></tr>
<tr><td>Other</td><td>5</td><td>Final exam</td><td>50</td></tr>
<tr><td>Total</td><td>100</td><td></td><td></td></tr>
<tr><td colspan="2"></td><td>Total</td><td>100</td></tr>
</table>

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	**Educational Physics**

Course name	**QUANTUM MECHANICS II**

Course ID	Semester	Course status	ECTS credits	L+E
PTH6711	**VI**	**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 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.

Course content

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.

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 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.

Remarks

Program	Level of studies		**First cycle**	
	Program name		**Educational 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 to statistical physics by lectures and exercises. Expected outcomes: Adopting the basic ideas and concepts of equilibrium statistical physics. Mastering the mathematical apparatus of classical and quantum statistical physics. Getting acquainted with the applications of equilibrium statistical physics.			

Course content

Goal and methods of the statistical physics
Elements of 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	Partial 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

<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">SPECIAL THEORY OF RELATIVITY</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>PTH6511</td><td>VI</td><td>MANDATORY</td><td>5</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Elvedin Hasović</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The goal of the course is to 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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 the 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.</td></tr>
<tr><td colspan="2">Student workload (hours)</td><td colspan="3">Grading</td></tr>
<tr><td>Lectures and Exercises</td><td>60</td><td>Assessment method</td><td colspan="2">Points</td></tr>
<tr><td>Exam preparation</td><td>65</td><td>Course Test</td><td colspan="2">50</td></tr>
<tr><td>Total</td><td>120</td><td>Final Exam</td><td colspan="2">50</td></tr>
<tr><td colspan="2"></td><td>Total</td><td colspan="2">100</td></tr>
<tr><td colspan="5">Literature</td></tr>
<tr><td colspan="5">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.</td></tr>
<tr><td colspan="5">Remarks</td></tr>
<tr><td colspan="5"></td></tr>
</table>

<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">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS EDUCATION 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>PED6611</td><td>VI</td><td>MANDATORY</td><td>6</td><td>4+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Vanes Mešić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to develop 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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.</td></tr>
</table>

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	**Educational Physics**
Course name	**LABORATORY IN PHYSICS EDUCATION II**	

Course ID	Semester	Course status	ECTS credits	L+E
PED6311	**VI**	**MANDATORY**	**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 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">HISTORY OF 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>PHY6311</td><td>VI</td><td>MANDATORY</td><td>2</td><td>2+0</td></tr>
<tr><td>Lecturer</td><td colspan="4">Doc. dr. Amra Salčinović fetić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The goal of this course is to cover the history of natural science. Special attention is devoted to presenting the development of the most important physics principles 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 physics developed in a historical context.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">History of sciences in early cultures (5000-600 BC). Babylonia. Egypt. Phoenicia. India. China and the 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. Maricourt. Occam. Buridan. The mean speed theorem. 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 the atom. Rutherford. Other particles. Quantum theory. Bohr. Planck. Heisenberg. The principle of uncertainty. De Broglie. Pauli. Schrödinger. Dirac. Fermi. Astrophysics. Other developments in modern physics.</td></tr>
</table>

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 an 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.

FOURTH YEAR

(VII AND VIII SEMESTER)

Program	Level of studies		**First cycle**	
	Program name		**Educational 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 successfully 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 examinations are 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">Educational physics</td></tr>
<tr><td>Course name</td><td colspan="4">ADVANCED PHYSICS LABORATORY 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>PCM7311</td><td>VII</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 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Study of crystal structures. The Franck-Hertz experiment. Thermionic emission. Certain physical properties of semiconductors. Thermoelectric phenomena in semiconductors. Nuclear magnetic resonance.</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 I, nerecenzirana interna skript
2. Ch. Kittel: Uvod u fiziku čvrstog stanja, Savremena administracija, Beograd, 1970.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

<table>
<tr><td rowspan="2">Study program</td><td>Level of the study program</td><td colspan="2">First cycle</td></tr>
<tr><td>Name of the study program</td><td colspan="2">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">LABORATORY IN PHYSICS EDUCATION III</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PED7411</td><td>VII</td><td>MANDATORY</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.
6. Solve experimental exercises and laboratory problems.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Introducing the students with the syllabus.
Independence of perpendicular components of motion. Projectile motion.
Rotational motion.
Conservation laws in mechanics.
Fluid dynamics.
Basics of thermodynamics and molecular kinetic theory.
Mechanical oscillations and waves - part I.
Mechanical oscillations and waves - part II.
Direct current. Electric current in fluids.
Alternating current. Electromagnetic oscillations and waves.</td></tr>
</table>

<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>25</td><td>Partial exam</td><td>30</td></tr>
<tr><td>Assignments</td><td>25</td><td>Experimental exercises and laboratory problems</td><td>10</td></tr>
<tr><td>Other</td><td>5</td><td>Project</td><td>10</td></tr>
<tr><td>Total</td><td>100</td><td>Final exam</td><td>50</td></tr>
<tr><td colspan="2"></td><td>Total</td><td>100</td></tr>
</table>

Literature

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

Remarks

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

<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">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">PHYSICS TEACHING PRACTICE 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>PED7511</td><td>VII</td><td>MANDATORY</td><td>5</td><td>3+2</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Vanes Mešić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to further develop students' skills of planning, conducting and analyzing physics lessons, as well as in deepening students' understanding of selected physics topics.
Intended learning outcomes:
1. Create a portfolio which documents development of skills related to planning and analysing physics lessons.
2. Conduct physics lessons in the faculty classroom environment.
3. Observe and analyse physics lessons and engage in self-reflection.
4. Identify students' misconceptions and facilitate the process of conceptual change.
5. Demonstrate deep conceptual understanding of physics topics that are part of the physics curricula in Canton Sarajevo.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">Role of teaching practice within initial physics teacher education. Developing a work plan for physics teaching practice. Portfolio: role, structure, process of learning. Physics curriculum: actual physics curricula, core curricula and school curricula, differentiating curricula. Developing work plans in physics education. Physics textbooks and other educational media. Model of physics lesson plans. Guidelines for observing and evaluating physics lessons. Simulation and evaluation of physics lessons within the faculty classroom environment – level of secondary school. Simulation and evaluation of physics lessons within the faculty classroom environment – level of primary school.</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>30</td><td>Portfolio</td><td>15</td></tr>
<tr><td>Assignments</td><td>15</td><td>Partial exam</td><td>35</td></tr>
<tr><td>Other</td><td>5</td><td>Final exam</td><td>50</td></tr>
<tr><td>Total</td><td>125</td><td></td><td></td></tr>
<tr><td colspan="2"></td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">1. Muratović, H., Mešić, V. (2009). Didaktičko-metodički prilozi nastavi fizike. Sarajevo: Prirodno-matematički fakultet.
2. Physics textbooks for the primary and secondary school level.
3. Lemov, D. (2015). Teach like a champion 2.0: 62 techniques that put students on the path to college. John Wiley & Sons.</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

Program	Level of studies		**First cycle**	
	Program name		**Educational Physics**	
Course name	**SOLID STATE PHYSICS I**			
Course ID	Semester	Course status	ECTS	L+E
PCM5611	**VII**	**MANDATORY**	**6**	**2+2**
Lecturer	**Doc. Dr. Maja Đekić**			
Aims and intended learning outcomes	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			

Course content

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. Bragg's law. Atomic scattering factor. Structure factor. TYPES OF BONDS IN CRYSTAL-ionic, covalent, metal, van der Waals. 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-Dulong-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.

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

Study program	Level of the study program		**First cycle**	
	Name of the study program		**Educational Physics**	
Course name	**INCLUSION IN PHYSICS EDUCATION**			
Course ID	Semester	Course status	ECTS credits	L+E
PED7311	**VII**	**MANDATORY**	**3**	**2+1**
Lecturer	**Prof. dr. Vanes Mešić**			
Aims and intended learning outcomes	The aim of this course is to further develop students' skills of planning, conducting and analyzing inclusive physics lessons. Intended learning outcomes: 1. Explain the concepts of differentiated instruction and inclusion. 2. Describe strategies for identifying students with special needs and develop an individualized education program. 3. Specify the general guidelines for implementing inclusive teaching. 4. Describe strategies for tailoring physics instruction to the needs of different categories of students. 5. Create a portfolio which documents development of skills related to planning, conducting and analysing inclusive physics lessons.			

Course content

Differentiated physics instruction. Concept of inclusion. Identifying students with special needs. Development of individualized education programs. School-family partnership within the context of inclusive education. General guidelines for implementation of inclusive instruction. INCLUDE strategy.
Specific learning disabilities. Communication disorders. Mental retardation.
Emotional disturbance and behavioral disorders. Attention deficit/Hyperactivity disorder. Autistic spectrum disorder. Hearing impairments. Visual impairments. Physical disabilities.
The needs of gifted students.
Time and resource management. Peer assistance and peer tutoring. Evaluation.
Strategies for managing classroom behavior. Strategies for improving motivation, attention and memory. Modern technologies in inclusive instruction.
Guidelines for implementing activities in the inclusive physics classroom. Observing, classifying and measuring. Recording and handling experimental data. Invention and discovery activities. Magnetism and electricity activities. Force and motion activities. Sound, light and color activities. Solids/liquids/gases activities.

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	15	Portfolio	15
Assignments	10	Partial exam	35
Other	5	Final exam	50
Total	75		
		Total	100

Literature

1. Muratović, H., Mešić, V. (2009). *Didaktičko-metodički prilozi nastavi fizike*. Sarajevo: Prirodno-matematički fakultet.
2. Friend, M., Bursuck, W. D. (2012). *Including Students with Special Needs: A Practical Guide for Classroom Teachers*. Boston, MA: Pearson.
3. Brigham, F. J., Scruggs, T. E., & Mastropieri, M. A. (2011). Science education and students with learning disabilities. *Learning Disabilities Research & Practice*, *26*(4), 223-232.
4. Mastropieri, M. A., & Scruggs, T. E. (1993). *A Practical Guide for Teaching Science to Students with Special Needs in Inclusive Settings*. West Lafayette, IN: Pro-ed.
5. STC (2015). *Unapređenje obrazovnog sistema u oblasti primjene inkluzivnih principa poučavanja – publikacija stručnih radova i izlaganja sa stručnog simpozijuma*. Sarajevo: Save the Children.

Remarks

<table>
<tr><td rowspan="2">Program</td><td colspan="2">Level of studies</td><td colspan="3">First cycle</td></tr>
<tr><td colspan="2">Program name</td><td colspan="3">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="5">COMPUTATIONAL PHYSICS II</td></tr>
<tr><td>Course ID</td><td>Semester</td><td colspan="2">Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PCS8611</td><td>VIII</td><td colspan="2">MANDATORY</td><td>6</td><td>2+2</td></tr>
<tr><td>Lecturer</td><td colspan="5">Prof. dr. Senad Odžak</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="5">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 modelling 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="6">Course content</td></tr>
<tr><td colspan="6">Numerically solving 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>
<tr><td colspan="3">Student workload (hours)</td><td colspan="3">Grading</td></tr>
<tr><td>Lectures and Exercises</td><td colspan="2">75</td><td>Assessment method</td><td colspan="2">Points</td></tr>
<tr><td>Exam preparation</td><td colspan="2">70</td><td>Course Tests
(Multiple assignments)</td><td colspan="2">60</td></tr>
<tr><td>Assignments</td><td colspan="2">0</td><td>Final Exam (Theory)</td><td colspan="2">40</td></tr>
<tr><td>Other</td><td colspan="2">5</td><td></td><td colspan="2"></td></tr>
<tr><td>Total</td><td colspan="2">150</td><td></td><td colspan="2"></td></tr>
<tr><td colspan="3"></td><td>Total</td><td colspan="2">100</td></tr>
<tr><td colspan="6">Literature</td></tr>
<tr><td colspan="6">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.</td></tr>
<tr><td colspan="6">Remarks</td></tr>
<tr><td colspan="6">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.</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">Educational 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>

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 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

Remarks

Study program	Level of the study program		**First cycle**	
	Name of the study program		**Educational Physics**	
Course name	**LABORATORY IN PHYSICS EDUCATION IV**			
Course ID	Semester	Course status	ECTS credits	L+E
PED8421	**VIII**	**MANDATORY**	**4**	**0+3**
Lecturer	**Prof. dr. Vanes Mešić**			
Aims and intended learning outcomes	The aim of this course is to develop students' knowledge, skills and habits that are important for effective implementation of the experimental method in physics classrooms with particular focus on use of modern technologies and experimental projects. Intended learning outcomes: 1. Systematically prepare, conduct, evaluate and present physics experiments. 2. Perform digital video analysis of selected physics phenomena and demonstrate the ability to use microcomputer-based laboratories in the physics classroom. 3. Demonstrate virtual physics experiments and solve virtual laboratory problems. 4. Prepare, implement and present experimental projects in physics.			

Course content

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

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

Literature

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

Remarks

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

Study program	Level of the study program		**First cycle**	
	Name of the study program		**Educational Physics**	
Course name	**PHYSICS TEACHING PRACTICE II**			
Course ID	Semester	Course status	ECTS credits	L+E
PED8511	**VIII**	**MANDATORY**	**5**	**3+2**
Lecturer	**Prof. dr. Vanes Mešić**			
Aims and intended learning outcomes	The aim of this course is to further develop students' skills of planning, conducting and analyzing physics lessons in faculty and school environment, as well as in deepening students' understanding of selected physics topics. Intended learning outcomes: 1. Create a portfolio which documents development of skills related to planning and analysing physics lessons. 2. Conduct physics lessons in the faculty classroom and school environment. 3. Observe and analyse physics lessons and engage in self-reflection. 4. Identify students' misconceptions and facilitate the process of conceptual change. 5. Demonstrate deep conceptual understanding of physics topics that are part of the physics curricula in Canton Sarajevo.			

Course content

Developing a plan of teaching practice in the school environment.
Developing a plan of teaching practice in the faculty classroom environment.
Observing and simulating classes in the faculty classroom environment.
Analysing physics classes that had been conducted in the faculty classroom environment.
Observing and conducting classes in the authentic school environment.
Analysing physics classes that had been conducted in the school environment.
Reflection on teaching practice experiences and discussion about students' portfolios.

Student workload (hours)		Grading	
Lectures and Exercises	75	Assessment method	Points
Exam preparation	30	Portfolio	15
Assignments	15	Partial exam	35
Other	5	Final exam	50
Total	125		
		Total	100

Literature

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

Remarks

Program	Level of studies	**First cycle**
	Program name	**Educational Physics**
Course name	**SOLID STATE PHYSICS II**	

Course ID	Semester	Course status	ECTS	L+E
PCM6511	**VIII**	**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 – 9th week of classes

Program	Level of studies	**First cycle**
	Program name	**Educational Physics**
Course name	**DIDACTICS**	

Course ID	Semester	Course status	ECTS	L+E
PED8412	**VIII**	**MANDATORY**	**4**	**2+1**

Lecturer	**Prof. Dr. Hasnija Nurković**
Aims and intended learning outcomes	The aim of this course is to explore fundamental problems related to didactic theory and educational practice.

Course content

- 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

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	45	Presence and activity	20
Assignments	10	First partial exam	30
		Final exam	50
Total	100	Total	100

Literature

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.

Remarks

LIST OF POSSIBLE ELECTIVE COURSES IN FIRST YEAR

Program	Level of studies		**First cycle**	
	Program name		**Educational 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	**Prod. 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 basics 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

<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">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">COMMUNICATION SKILLS FOR PHYSICISTS</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS credits</td><td>L+E</td></tr>
<tr><td>PED1311</td><td>I</td><td>ELECTIVE</td><td>3</td><td>2+1</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 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">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.</td></tr>
</table>

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

Program	Level of studies		**First cycle**	
	Program name		**Educational Physics**	
Course name	**INTRODUCTION TO COMPUTER SCIENCE FOR PHYSICISTS II**			
Course ID	Semester	Course status	ECTS credits	L+E
PCS2211	**II**	**ELECTIVE**	**2**	**0+2**
Lecturer	**Prof. dr. Senad Odžak**			
Aims and intended learning outcomes	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.			

Course content
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.

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.

<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">ENGLISH LANGUAGE</td></tr>
<tr><td>Course ID</td><td>Semester</td><td>Course status</td><td>ECTS</td><td>L+E</td></tr>
<tr><td>POT2211</td><td>I</td><td>ELECTIVE</td><td>2</td><td>2+0</td></tr>
<tr><td>Lecturer</td><td colspan="4"></td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of 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 world events at all.
During 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.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">English language system. Significance and distinction of minimum pairs. Pronunciation exercise. English alphabet. Spelling exercises. 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.</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>20</td><td>Midterm exam</td><td>50</td></tr>
<tr><td>Total</td><td>50</td><td>Final exam</td><td>50</td></tr>
<tr><td></td><td></td><td>Total</td><td>100</td></tr>
<tr><td colspan="4">Literature</td></tr>
<tr><td colspan="4">1. H. F. Brookes, H. Ross: “English as a foreign language for science students”, Heinmann Educational Books, London (I i II dio)</td></tr>
<tr><td colspan="4">Remarks</td></tr>
<tr><td colspan="4"></td></tr>
</table>

LIST OF POSSIBLE ELECTIVE COURSES IN FOURTH YEAR

Program	Type of study (cycle)		**First cycle**	
	Name of the program		**Educational Physics**	
Name of the course	**ELECTRICAL MEASUREMENTS OF NON-ELECTRIC QUANTITIES**			
Course ID	Semester	Course status	ECTS credits	L+E
PCM6411	**VIII**	**ELECTIVE**	**4**	**2+1**
Professor	**Prof. dr. Edvin Skaljo,**			
Aims and intended learning outcomes	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.			

Course content
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.

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

Literature
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

Remarks

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

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

Course ID	Semester	Course status	ECTS credits	L+E
PHY5421	**VII**	**ELECTIVE**	**4**	**0+3**

Lecturer	**Doc. Dr. Maja Đekić**
Aims and intended learning outcomes	Laboratory exercises are designed to enable students to apply acquired knowledge from general physics courses. By working with experimental equipment using simple measurement instrumentation and parts, from optical to semiconductors, 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 general 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 a reversible pendulum.
4. Measuring Planck's constant using a photoresistor.
5. Analysing current-voltage characteristics of a semiconductor photocell.
6. Analysing current-voltage characteristics of a LED
7. Electrical conductivity of a thin layer.
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.

Study program	Level of the study program	**First cycle**
	Name of the study program	**Educational Physics**
Course name	**APPLICATIONS OF PHYSICS IN EVERYDAY LIFE AND TECHNOLOGY**	

Course ID	Semester	Course status	ECTS credits	L+E
PHY7311	**VII**	**ELECTIVE**	**3**	**3+0**

Lecturer	**Prof. dr. Vanes Mešić**
Aims and intended learning outcomes	The aim of this course is to further develop students' understanding of physics within the context of everyday life and technology. Intended learning outcomes: 1. Explain selected phenomena from everyday life by using laws of physics. 2. Use physics knowledge in order to analyse the working principles of selected technical devices. 3. Discuss the complex relationship between physics, technology and society.

Course content
Laws of motion – Part I (skating, projectile motion, ramps). Laws of motion – Part II (seesaws, wheels, bumper cars). Mechanical objects – Part I (spring scales, ball sports, carousels and roller coasters). Mechanical objects – Part II (bicycles, rockets and space travel). Fluids (balloons, water distribution, aerodynamics and ball sports, planes). Heat and phase transitions (wood stoves, light bulb, clothing, insulation and climate). Thermodynamics (air conditioners, automobiles). Mechanical waves and resonance (clocks, musical instruments). Electricity (xerographic copiers, flashlights). Magnetism and electrodynamics (magnets, electric power distribution, electric generators and motors). Electromagnetic waves (radio, microwave oven). Light (discharge lamps, lasers and LEDs). Optics and electronics (cameras, optical recording and communication, audio player). Modern physics (nuclear weapons, nuclear reactors, medical imaging and radiation).

Student workload (hours)		Grading	
Lectures and Exercises	45	Assessment method	Points
Exam preparation	15	Partial exam	30
Assignments	10	Seminar paper	20
Other	5	Homework	10
Total	75	Final exam	40
		Total	100

Literature
1. University physics textbooks. 2. Bloomfield, L. A. (2013). *How Things Work: The Physics of Everyday Life*. John Wiley & Sons. 3. Bloomfield, L. A. (2007). *How Everything Works: Making Physics Out of the Ordinary*. John Wiley & Sons. 4. Knight, J., Schlager, N. (2001). *Science of Everyday Things: Volume 2. Real-Life Physics*. Gale Group Staff. 5. Selected articles from physics education journals.

Remarks

<table>
<tr><td rowspan="2">Study program</td><td colspan="2">Level of the study program</td><td colspan="2">First cycle</td></tr>
<tr><td colspan="2">Name of the study program</td><td colspan="2">Educational Physics</td></tr>
<tr><td>Course name</td><td colspan="4">EVOLUTION OF PHYSICAL THEORIES</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>PHY8311</td><td>VIII</td><td>ELECTIVE</td><td>3</td><td>2+0</td></tr>
<tr><td>Lecturer</td><td colspan="4">Prof. dr. Vanes Mešić</td></tr>
<tr><td>Aims and intended learning outcomes</td><td colspan="4">The aim of this course is to further develop the students' understanding about the evolution of physics, from the rise of the mechanical view to development of quantum physics.
Intended learning outcomes:
1. Describe and interpret the evolution of selected physical theories.
2. Analyse the nature of scientific discovery within the context of development of specific physics concepts and theories.
3. Relate the development of ideas throughout history of physics with the development of corresponding ideas in an individual.</td></tr>
<tr><td colspan="5">Course content</td></tr>
<tr><td colspan="5">The rise of the mechanical view– part 1 (Vectors. Motion). The rise of the mechanical view– part 2 (The heat concept). The rise of the mechanical view– part 3 (Molecular-kinetic theory. The philosophical background of the mechanical view). The decline of the mechanical view - part 1 (Electric fluid. Magnetic fluid). The decline of the mechanical view – part 2 (Light as substance. Velocity of light. The color concept). The decline of the mechanical view – part 3 (The wave concept. Wave theory of light. Ether and the mechanical view). The field concept and relativity – part 1 (Field as representation. The reality of the field. Field and ether). The field concept and relativity – part 2 (Ether and motion. Time, distance and relativity). The field concept and relativity – part 3 (Relativity and mechanics. Time-space continuum). The field concept and relativity – part 3 (General relativity. Geometry and experiments). Quantum physics – part 1 (Continuity and discontinuity. Elementary quanta). Quantum physics– part 2 (Electromagnetic spectrum. Waves of matter). Quantum physics – part 3 (Probabilistic laws. Physics and reality). Current challenges. Theory of everything.</td></tr>
</table>

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

Literature

1. Supek, I. (1995). *Filozofija, znanost i humanizam.* Zagreb: Školska knjiga
2. Einstein, A., & Infeld, L. (1967). *The evolution of physics: the growth of ideas from early concepts to relativity and quanta*. NY: Touchstone.
3. Torretti, R. (1998). The Philosophy of Physics. Cambridge: CUP.

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">Educational 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>ELECTIVE</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. Photons, mezons, antiparticles, neutrinos, 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