DEPARTMENT OF PHYSICS, UNIVERSITY OF RIJEKA

# UNDERGRADUATE STUDY PROGRAMME PHYSICS

-Course descriptions

MAY, 2020.

***Sveučilište u Rijeci • University of Rijeka***

Trg braće Mažuranića 10 • 51 000 Rijeka • Croatia
T: (051) 406-500 • F: (051) 216-671; 216-091
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## List of compulsory and elective courses and/or modules with teaching hours required and ECTS credits allocated

- **Physics**

| LIST OF MODULES/COURSES | | | | | | |
|---|---|---|---|---|---|---|
| **Semester:** 1. | | | | | | |
| | **COURSE** | **L** | **E** | **S** | **ECTS** | **STATUS** |
| | Physics I: Mechanics | 45 | 45 | 0 | 8 | C |
| | Fundamentals of Computer Science | 15 | 15 | 0 | 3 | E |
| | Basic Mathematics | 15 | 15 | 0 | 3 | E |
| | Nontraditional Physics Problems | 15 | 0 | 15 | 3 | E |
| **Semester:** 2. | | | | | | |
| | Physics II: Electricity and Magnetism | 45 | 45 | 0 | 8 | C |
| | Data Analysis | 30 | 30 | 0 | 4 | C |
| **Semester:** 3. | | | | | | |
| | Physics III: Waves and Optics | 45 | 30 | 0 | 7 | C |
| | Physics Laboratory I | 0 | 0 | 45 | 3 | C |
| | Mathematical Methods of Physics I | 30 | 30 | 0 | 5 | E |
| | Modern Physics I | 60 | 15 | 15 | 6 | E |
| | Modern Physics I | 60 | 15 | 0 | 5 | E |
| | Classical Mechanics I | 45 | 45 | 15 | 9 | E |
| **Semester:** 4. | | | | | | |
| | Physics IV: Thermodynamics and Basic Statistical Physics | 60 | 30 | 0 | 8 | C |
| | Physics Laboratory II | 0 | 0 | 45 | 3 | C |
| | Modern Physics II | 60 | 15 | 15 | 6 | C |
| | Mathematical Methods of Physics II | 30 | 30 | 0 | 5 | E |
| | Classical Mechanics II | 45 | 30 | 15 | 8 | E |
| | Chemistry I | 30 | 10 | 30 | 8 | E |
| **Semester:** 5. | | | | | | |
| | Physics Laboratory III | 0 | 0 | 45 | 3 | C |
| | Electrodynamics | 45 | 45 | 15 | 12 | E |
| | Classical Mechanics | 45 | 45 | 0 | 7 | E |
| | Measurements in Physics | 30 | 15 | 15 | 5 | E |
| | Computational Physics | 30 | 15 | 15 | 5 | E |
| | General Chemistry | 30 | 0 | 15 | 5 | E |
| | Mathematical models in natural sciences and humanities | 30 | 15 | 15 | 5 | E |
| | Chemistry II | 30 | 0 | 30 | 7 | E |
| | Environmental physics | 20 | 10 | 10 | 5 | E |

C – compulsory, E - elective

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| LIST OF MODULES/COURSES | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Semester:** 6. | | | | | | | |
| | **COURSE** | | **L** | **E** | **S** | **ECTS** | **STATUS** |
| | Physics Laboratory IV | | 0 | 0 | 60 | 6 | C |
| | Methodology of Writing and Presenting Professional and Scientific Work | | 20 | 0 | 40 | 4 | E |
| | Methodology of Elaborating Professional and Scientific Work | | 15 | 0 | 15 | 1 | E |
| | Quantum Mechanics | | 45 | 45 | 15 | 12 | E |
| | Laboratory Project | | 0 | 0 | 30 | 3 | E |
| | Symbolic Programming | | 15 | 15 | 0 | 3 | E |
| | Fundamentals of Astronomy and Astrophysics | | 30 | 0 | 15 | 4 | E |
| | Physics Seminars | | 0 | 0 | 30 | 3 | E |
| | Physical Chemistry | | 30 | 30 | 0 | 6 | E |

C – compulsory, E - elective

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| Basic description | | |
|---|---|---|
| **Course coordinator** | Velimir Labinac | |
| **Course title** | BASIC MATHEMATICS | |
| **Study programme** | Undergraduate Study Programme Physics | |
| **Course status** | Elective | |
| **Year** | 1. year | |
| **ECTS credits and teaching** | **ECTS student 's workload coefficient** | 3 |
| | **Number of hours (L+E+S)** | 15 + 15 + 0 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

The main objectives of the course Basic Mathematics are to renew and to supplement basic knowledge of secondary school mathematics. The course will certainly help students to master more advanced topics from higher courses (Mathematical Analysis I, II, Linear Algebra I, II). An oral exam will not include the mathematical proofs of some theorems which will be presented on lectures. Instead, students will be asked to know only basic definitions and facts necessary to solve concrete problems. On the other hand, homework will contain usual problems as well as elementary proofs. It is important that students understand the logic of mathematical reasoning IF - THEN so they could use it to solve problems in physics.

### 1.2. Course enrolment requirements

Students can enrol this course at no additional requirements.

### 1.3. Expected course learning outcomes

After completing the course and passing the exam, students are expected to be able to:
• define the principle of mathematical induction and apply it to simple tasks;
• know the definitions and graphs of elementary functions: linear, quadratic, cubic, exponential and hyperbolic, logarithmic and area, trigonometric and cyclometric;
• know the basic properties of complex numbers and calculate operations with them;
• solve a simple system of linear equations, quadratic and cubic equations, and use the Mathematica software package (SOLVE command) to solve more complex algebraic equations;
• can solve transcendental equations that include exponential, logarithmic and trigonometric equations;
• know how to express the basic theorem of algebra;
• know how to recognize arithmetic and geometry and use known formulas to sum the first n terms;
• solve typical plane trigonometry tasks and demonstrate the validity of simple trigonometric identities;
• list the basic properties of line, circle, parabola, ellipse and hyperbola;
• define the definition of a derivative, an indefinite and a definite integral and apply them to simple tasks in general physics.

### 1.4. Course content

Fundamentals of mathematical logic. Sets, relations, functions and numbers. Methods of proof. Elementary number theory. Definitions of elementary functions, graphs, and the associated properties: polynomial, rational, irrational, exponential, logarithmic, trigonometric, inverse trigonometric, hyperbolic and area functions. Complex numbers. Sequences and series. Inequalities. Algebraic and transcendental equations and inequalities. Trigonometric identities. Plane trigonometry. Analytical geometry in the plane. The basics of calculus.

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| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### *1.7. Student's obligations*

Students are obligated:

- to attend regularly and to participate actively in lectures and exercises;
- to do their homework independently;
- to write a brief 5 min seminar paper with PowerPoint presentation; seminar topics will include additional topics or proofs of simple theorems;
- to pass two midterms and final oral exam.

### *1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 0.8 | Activity/Participation | 0.2 | Seminar paper | 0.2 | Experimental work | |
| Written exam | 1.0 | Oral exam | 0.4 | Essay | | Research | |
| Project | | Sustained knowledge check | 0.2 | Report | 0.2 | Practice | |
| Portfolio | | | | | | | |

### *1.9. Assessment and evaluation of student's work during classes and on final exam*

Student will be evaluated and assessed during the course and final exam. Maximum total percentage which student can achieve during the lessons is 70%, while the final exam provides 30% at best.
Detailed elaboration of ways of monitoring and evaluation of students' work will be displayed in the Working Plan!

### *1.10. Assigned reading (at the time of the submission of study programme proposal)*

Bronshtein I. N., et al., *Handbook of Mathematics*, 4th edition, Golden Marketing, Zagreb, 2004. (in croatian)

### *1.11. Optional / additional reading (at the time of proposing study programme)*

Antonov N, i dr., *Problems in Elementary Mathematics for Home Study*, Mir Publishers, Moscow, 1982.
Baranov I., Bogatyrev G., Bokovnev O., *Mathematics for Pre-college Students*, Mir Publishers, Moscow, 1985.
Dorofeev G., *Elementary Mathematics – Selected Topics and Problem Solving*, 4th ed., Mir Publishers, Moscow, 1988.
Kruglak H., Moore J.T. *Schaum's Outline of Theory and Problems of Basic Mathematics*, 2nd ed., McGraw-Hill, New York, 1998.
Kutepov A., Rubanov A., *Problem book: Algebra and Elementary Functions*, Mir Publishers, Moscow, 1978.
Lidsky V., i dr., *Problems in Elementary Mathematics*, Mir Publishers, Moscow, 1973.
Litvinenko V., Mordkovich A., *Solving Problems in Algebra and Trigonometry*, Mir Publishers, Moscow, 1987.
Mintaković S., Ćurić F., *Matematika sa zbirkom zadataka*, 6. izdanje, Školska knjiga, Zagreb, 2003.
Moyer R. E., Ayres F. Jr., *Schaum's Outline of Trigonometry*, 4nd ed., McGraw-Hill, New York, 2009.
Pavković B. Veljan D., *Elementarna matematika I*, Školska knjiga, Zagreb, 1995.
Pavković B. Veljan D., *Elementarna matematika II*, Školska knjiga, Zagreb, 1995.
Pavković B., Svrtan D., Veljan D., *Matematika 3. – zbirka zadataka*, Školska knjiga, Zagreb, 1995.
Prilepko A. I., *Problem Book in High-School Mathematics*, Mir Publishers, Moscow, 1985.
Rich B., *Schaum's Outline of Theory and Problems of Review of Elementary Mathematics*, 2nd ed., McGraw-Hill, New York, 1997.
Safier F., *Schaum's Outline of Precalculus*, 2nd ed., McGraw-Hill, New York, 2009.
Schmidt P., Steiner R. V., *Schaum's Outline of Mathematics for Physics Students*, McGraw-Hill, New York, 2007.
Shklyarsky D. O., *Selected Problems and Theorems in Elementary Mathematics – Arithmetics and Algebra*, Mir Publishers, Moscow, 1979.

Sošić M., Marinović, *Repetitorij s riješenim zadacima iz matematike*, Filozofski fakultet u Rijeci, Rijeka, 2004.
Yakovlev G. N., *High-School Mathematics*, part 1, Mir Publishers, Moscow, 1988.
Yakovlev G. N., *High-School Mathematics*, part 2, Mir Publishers, Moscow, 1988.

WWW
http://mthwww.uwc.edu/wwwmahes/files/math01.htm
http://freebookcentre.net/Mathematics/Trigonometry-Books-Download.html
http://www.cosc.brocku.ca/~duentsch/papers/methprimer1.html
http://web.math.hr/nastava/em/

**1.12. Number of assigned reading copies with regard to the number of students currently attending the course**

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Bronshtein I. N., et al., *Handbook of Mathematics*, 4th edition, Golden Marketing, Zagreb, 2004. (in croatian) | 3 | 10-20 |

**1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences**

Regular monitoring of the student's activity and attitude towards work. In the last week of classes, anonymous surveys will be conducted in which students will evaluate the quality of teaching. At the end of each semester (1 March and 30 September of the current academic year) student' success in examinations will be analyzed.

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| **Basic description** | | |
|---|---|---|
| ***Course coordinator*** | Assoc. Prof. Gabriela Ambrožić | |
| ***Course title*** | Chemistry I | |
| ***Study programme*** | Undergraduate Study Programme in Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 2nd | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 8 |
| | ***Number of hours (L+E+S)*** | 30 L + 10 E + 30 S |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

Mastering the basics of chemistry.

### 1.2. Course enrolment requirements

Achieved enrollment for the undergraduate programme.

### 1.3. Expected course learning outcomes

After passing the exam, students will be able to:
- explain the electronic structure of atoms and the position of elements in the periodic table;
- explain the properties of elements based on electronic configuration;
- define the types of bonds in compounds and on that basis predict their chemical properties;
- explain the properties of the substance depending on the physical state;
- define the rate of a chemical reaction and explain the influence of various factors on the rate of chemical reactions;
- distinguish between weak and strong electrolytes;
- explain the chemical equilibrium in weak electrolyte solutions.

### 1.4. Course content

Atoms and elements
Molecules, compounds
Chemical equations
Stoichiometry
Quantum-mechanical model of atoms
Periodic properties of the elements
Chemical bonding (Lewis model, molecule shapes, valence bond theory, molecular orbital theory
Gases
Thermochemistry
Liquids, solids and intermolecular forces
Solutions
Chemical kinetics
Chemical equilibrium
Acids and bases
Equilibrium in aqueous solutions

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | X lectures<br>X seminars and workshops<br>X exercises<br>X long distance education | ☐ individual assignment<br>☐ multimedia and network<br>X laboratories<br>☐ mentorship |

| | | |
|---|---|---|
| | ☐ fieldwork | ☐ other |
| ***1.6. Comments*** | | |

***1.7. Student's obligations***

Attending lectures and seminars, solving homework and taking exams.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2.5 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 2.5 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 3.0 | Report | | Practice | |
| Portfolio | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

The grade from the course Chemistry I provides complete information about the performance of the candidate, and includes the results of the assessment through the conducted lectures and the final exam.
Continuous teaching consists of two tests in stoichiometry, laboratory exercises and regular course attendance.
The seminar consists of student solving tasks in stoichiometry. Laboratory exercises from individual teaching units will be defined for each academic year by the implementation program, depending on the number of students and the funds that will be available.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

1. Filipović, I; Lipanović, S.: Opća i anorganska kemija I, Školska knjiga, Zagreb, 1991
2. Sikirica M.: Stehiometrija, Školska knjiga, Zagreb.

***1.11. Optional / additional reading (at the time of proposing study programme)***

Nivaldo J. Tro, Chemistry–the molecular approach, 3th Edition, Pearson Education Inc., 2014

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | |
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***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

Constant interaction with students and stimulation of work students-teacher to promote the quality of teaching. Flexible adaptation of teaching to the interests and needs of students.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Assoc. Prof. Gabriela Ambrožić | |
| ***Course title*** | Chemistry II | |
| ***Study programme*** | Undergraduate Study Programme in Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3rd | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 7 |
| | ***Number of hours (L+E+S)*** | 30 L + 0 E + 30 S |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

Mastering the general and applied chemistry.

### 1.2. Course enrolment requirements

Passed exam in Chemistry I.

### 1.3. Expected course learning outcomes

After passing the exam, students will be able to:
- explain photochemical reactions and atmospheric pollution
- explain water purification methods
- determine qualitatively and quantitatively the relationships between matter and exchanged energy in a chemical or physical process.
- distinguish and explain redox and complex reactions
- predict the type of radioactivity
- explain the basic characteristics of organic molecules and polymers
- identify chemical components in cells
- explain the chemical properties of compounds with representative elements of the main group of the periodic table
- explain the chemical and physical properties of metals, alloys and transition metals

### 1.4. Course content

- Environmental chemistry
- Chemical thermodynamics
- Electrochemistry
- Radioactivity and nuclear chemistry
- Organic chemistry and polymer chemistry (basics)
- Biochemistry (basics)
- Chemistry of non-metals (basics)
- Metals and metallurgy (basics)
- Transition metals and coordinate covalent bonds (basics)

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | X lectures<br>X seminars and workshops<br>☐ exercises<br>X long distance education<br>☐ fieldwork | X individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### 1.7. Student's obligations

Attending lectures and seminars, solving homework and taking exams.

### 1.8. Evaluation of student's work

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2.0 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 2.0 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 2.0 | Report | | Practice | |
| Portfolio | | | | | | | |

### 1.9. Assessment and evaluation of student's work during classes and on final exam

The grade from the course Chemistry I provides complete information about the performance of the candidate, and includes the results of the assessment through the conducted lectures and the final exam.
Continuous teaching consists of two tests (stoichiometry) and regular course attendance.
The seminar consists of student solving tasks in stoichiometry.
The final oral exam contributes 30 points.

### 1.10. Assigned reading (at the time of the submission of study programme proposal)

1. Theodore E. Brown, H. Eugene LeMay Bruce E. Bursten Catherine Murphy , Patrick Woodward , Chemistry: The Central Science, 13th Ed., Pearson Education Inc., 2014.
2. Sikirica M.: Stehiometrija, Školska knjiga, Zagreb.

### 1.11. Optional / additional reading (at the time of proposing study programme)

Nivaldo J. Tro, Chemistry–the molecular approach, 3th Edition, Pearson Education Inc., 2014

### 1.12. Number of assigned reading copies with regard to the number of students currently attending the course

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
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### 1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences

Constant interaction with students and stimulation of work students-teacher to promote the quality of teaching. Flexible adaptation of teaching to the interests and needs of students.

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| Basic description | | |
|---|---|---|
| *Course coordinator* | Associate professor, Zoran Kaliman | |
| *Course title* | Classical Mechanics | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 3rd year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 7 |
| | *Number of hours (L+E+S)* | 45+45+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Developing mechanical concepts. To acquaint the students with mathematical skills as the basis for the theoretical physics.

### *1.2. Course enrolment requirements*

Prerequisites for this course are following: Mathematical Analysis I, II, Linear Algebra I, II, Physics I.
Course is in correlation with Classical mechanics 2, Electrodynamics and Quantum Mechanics.

### *1.3. Expected course learning outcomes*

***TENSOR CALCULUS***

1. To create and classify tensor equation, to compere tensor with matrix calculus.
2. To define and apply del operator, to check equations with del.

***NEWTON'S MECHANICS***

3. To define and apply Newton's law. To connect concepts learned in General physics with new mathematical apparatus
4. To derive and solve small oscillation problem. To find frequencies and normal coordinate.

***ANALITICAL MECHANICS***

5. To derive analytical mechanics equations.
6. To apply equations on specific problems.
7. To compare these methods between themselves and with Newton's law

***CENTRAL FORCES***

8. To derive equations for different kind of central forces. To define, derive, explain and apply Kepler's laws.
9. To define cross section. To calculate for some scatterings.

***MOTION IN NONINERTIAL SYSTEMS***

10. To derive equations of motion in accelerated coordinate system.

***SPECIAL RELATIVITY***

11. To describe Michelson-Morley experiment.
12. To define Einstein's postulates of special relativity. To derive and apply Lorentz transformations and consequences.

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*1.4. Course content*

Tensor calculus: Vector and tensors, vector analysis. Newtonian theory: Newton's laws and application. Analytical mechanics: Lagrangian method, constraints, Hamilton's equations. Small oscillations. Central forces: two body problem, Kepler's laws. Classical scattering theory. Motion in noninertial systems: Accelerated coordinate systems. Dynamics in a rotating coordinate system. Particle motion near surface of the Earth. The Faucault pendulum. Theory of special relativity: Lorentz transformations, Consequences of Lorentz transformations.

*1.5. Teaching methods*

- ☒ lectures
- ☐ seminars and workshops
- ☒ exercises
- ☐ long distance education
- ☐ fieldwork
- ☒ individual assignment
- ☒ multimedia and network
- ☐ laboratories
- ☒ mentorship
- ☐ other

*1.6. Comments*

*1.7. Student's obligations*

- Attendance at all classes and active participation is expected.
- Students should solve, write home works.
- Students should pass two preliminary exams (or written exam) in form of numerical exercises.
- Final oral exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3 | Activity/Participation | 0 | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 2 | Essay | | Research | |
| Project | | Sustained knowledge check | 2 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students will be evaluated during lectures and on final exam. Maximum percentage during lectures is 50%, and on final exam 50%. On final exam student should have at least 50% point to pass.
Detailed elaboration will be given in executive program.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. Kaliman Z., *Teorijska mehanika*, Filozofski fakultet u Rijeci, Rijeka, 2002.
2. Kaliman Z., Jelovica Badovinac I., Labinac V., Zbirka zadataka iz klasične mehanike 1, Odjel za fiziku Sveučilišta u Rijeci, 2016.
3. Spiegel M. R., *Theoretical mechanics*, Schaum Outline Series, McGraw-Hill Book Company, New York, 1967.
4. Wells D. A., *Lagrangian Dynamics*, Schaum Outline Series, McGraw-Hill Book Company, USA, 1967.

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Bradbury T. C., *Theoretical Mechanics*, John Wiley and Sons, New York, 1968.
2. Goldstein H., *Classical Mechanics*, Addison-Wesley Publishing Company, USA, 2nd edition, 1980.
3. Chow T. L., *Classical Mechanics*, John Wiley and Sons, USA, 1995.

4. Barger V. D., Olsson M. O., *Classical mechanics, a modern perspectives*, McGraw-Hill Book Company, New York, 1995.
5. Jose J. V., Saletan E. J., *Classical Dynamics: A Contemporary Approach*, Cambridge Univ Pr, 1998.
6. Landau L. D., Lifšic E. M., *Mehanika*, Građevinska knjiga, Beograd, 1961.
7. Supek I., *Teorijska fizika i struktura materije*, Tisak, Zagreb, 1974.
8. Zimmerman R. L., Olness F. I., *Mathematica for physics*, 2. izdanje, Addison Wesley, USA, 2003.
9. Feynman R., *Osobitosti fizikalnih zakona*, Školska knjiga, Zagreb, 1991.
10. Janković Z., *Teorijska mehanika*, Skripta PMF, Sveučilišna naklada Liber, Zagreb, 1976.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Kaliman Z., *Teorijska mehanika*, Filozofski fakultet u Rijeci, Rijeka, 2002. | 15 | 20-25 |
| Kaliman Z., Jelovica Badovinac I., Labinac V., Zbirka zadataka iz klasične mehanike 1, Odjel za fiziku Sveučilišta u Rijeci, 2016. | 15 | 20-25 |
| Spiegel M. R., *Theoretical mechanics*, Schaum Outline Series, McGraw-Hill Book Company, New York, 1967. | 3 | 20-25 |
| Wells D. A., *Lagrangian Dynamics*, Schaum Outline Series, McGraw-Hill Book Company, USA, 1967. | 3 | 20-25 |
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Discussions with the students, questionnaires, achievements on the exams. Regular monitoring students' activities.

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| Basic description | | |
|---|---|---|
| *Course coordinator* | Associate professor, Zoran Kaliman | |
| *Course title* | Classical Mechanics 1 | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | $2^{nd}$ year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 9 |
| | *Number of hours (L+E+S)* | 45+45+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Developing mechanical concepts. To acquaint the students with mathematical skills as the basis for the theoretical physics.

### *1.2. Course enrolment requirements*

Prerequisites for this course are following: Mathematical Analysis I, II, Linear Algebra I, II, Physics I.
Course is in correlation with Classical mechanics 2, Electrodynamics and Quantum Mechanics.

### *1.3. Expected course learning outcomes*

**TENSOR CALCULUS**

1. To create and classify tensor equation, to compere tensor with matrix calculus.
2. To define and apply del operator, to check equations with del.

**NEWTON'S MECHANICS**

3. To define and apply Newton's law. To connect concepts learned in General physics with new mathematical apparatus
4. To derive and solve small oscillation problem. To find frequencies and normal coordinate.

**ANALITICAL MECHANICS**

5. To derive analytical mechanics equations.
6. To apply equations on specific problems.
7. To compare these methods between themselves and with Newton's law

**CENTRAL FORCES**

8. To derive equations for different kind of central forces. To define, derive, explain and apply Kepler's laws.
9. To define cross section. To calculate for some scatterings.

**MOTION IN NONINERTIAL SYSTEMS**

10. To derive equations of motion in accelerated coordinate system.

**SPECIAL RELATIVITY**

11. To describe Michelson-Morley experiment.
12. To define Einstein's postulates of special relativity. To derive and apply Lorentz transformations and consequences.

*1.4. Course content*

Tensor calculus: Vector and tensors, vector analysis. Newtonian theory: Newton's laws and application. Analytical mechanics: Lagrangian method, constraints, Hamilton's equations. Small oscillations. Central forces: two body problem, Kepler's laws. Classical scattering theory. Motion in noninertial systems: Accelerated coordinate systems. Dynamics in a rotating coordinate system. Particle motion near surface of the Earth. The Faucault pendulum. Theory of special relativity: Lorentz transformations, Consequences of Lorentz transformations.

| *1.5. Teaching methods* | | |
|---|---|---|
| | ☒ lectures | ☒ individual assignment |
| | ☒ seminars and workshops | ☒ multimedia and network |
| | ☒ exercises | ☐ laboratories |
| | ☐ long distance education | ☒ mentorship |
| | ☐ fieldwork | ☐ other |

| *1.6. Comments* | |
|---|---|

*1.7. Student's obligations*

- Attendance at all classes and active participation is expected.
- Students should solve, write home works.
- Students should pass two preliminary exams (or written exam) in form of numerical exercises.
- Final oral exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3.5 | Activity/Participation | 0 | Seminar paper | 0.5 | Experimental work | |
| Written exam | | Oral exam | 2.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 2.5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students will be evaluated during lectures and on final exam. Maximum percentage during lectures is 50%, and on final exam 50%. On final exam student should have at least 50% point to pass.
Detailed elaboration will be given in executive program.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. Kaliman Z., *Teorijska mehanika*, Filozofski fakultet u Rijeci, Rijeka, 2002.
2. Kaliman Z., Jelovica Badovinac I., Labinac V., Zbirka zadataka iz klasične mehanike 1, Odjel za fiziku Sveučilišta u Rijeci, 2016.
3. Spiegel M. R., *Theoretical mechanics*, Schaum Outline Series, McGraw-Hill Book Company, New York, 1967.
4. Wells D. A., *Lagrangian Dynamics*, Schaum Outline Series, McGraw-Hill Book Company, USA, 1967.

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Bradbury T. C., *Theoretical Mechanics*, John Wiley and Sons, New York, 1968.
2. Goldstein H., *Classical Mechanics*, Addison-Wesley Publishing Company, USA, 2nd edition, 1980.
3. Chow T. L., *Classical Mechanics*, John Wiley and Sons, USA, 1995.

4. Barger V. D., Olsson M. O., *Classical mechanics, a modern perspectives*, McGraw-Hill Book Company, New York, 1995.
5. Jose J. V., Saletan E. J., *Classical Dynamics: A Contemporary Approach*, Cambridge Univ Pr, 1998.
6. Landau L. D., Lifšic E. M., *Mehanika*, Građevinska knjiga, Beograd, 1961.
7. Supek I., *Teorijska fizika i struktura materije*, Tisak, Zagreb, 1974.
8. Zimmerman R. L., Olness F. I., *Mathematica for physics*, 2. izdanje, Addison Wesley, USA, 2003.
9. Feynman R., *Osobitosti fizikalnih zakona*, Školska knjiga, Zagreb, 1991.
10. Janković Z., *Teorijska mehanika*, Skripta PMF, Sveučilišna naklada Liber, Zagreb, 1976.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Kaliman Z., *Teorijska mehanika*, Filozofski fakultet u Rijeci, Rijeka, 2002. | 15 | 20-25 |
| Kaliman Z., Jelovica Badovinac I., Labinac V., Zbirka zadataka iz klasične mehanike 1, Odjel za fiziku Sveučilišta u Rijeci, 2016. | 15 | 20-25 |
| Spiegel M. R., *Theoretical mechanics*, Schaum Outline Series, McGraw-Hill Book Company, New York, 1967. | 3 | 20-25 |
| Wells D. A., *Lagrangian Dynamics*, Schaum Outline Series, McGraw-Hill Book Company, USA, 1967. | 3 | 20-25 |
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Discussions with the students, questionnaires, achievements on the exams. Regular monitoring students' activities.

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*W: www.uniri.hr • E: ured@uniri.hr*

| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Associate professor, Zoran Kaliman | |
| *Course title* | Classical Mechanics 2 | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 2$^{rd}$ year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 8 |
| | *Number of hours (L+E+S)* | 45+30+15 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

To teach students some advanced topics in broad area of classical mechanics. Training students to independently analyse and solve involved realistic problems, not only in the realm of classical mechanics, but also in other contexts in which one can use mathematical techniques developed during the course. To acquaint students with knowledge necessary for understanding advanced theoretical courses.

### 1.2. Course enrolment requirements

Prerequisites for this course are following: Mathematical Analysis I, II, Linear Algebra I, II, Physics I.
Course is in correlation with Classical mechanics 2, Electrodynamics and Quantum Mechanics.

### 1.3. Expected course learning outcomes

**DYBAMICS OF RIGID BODIES**

1. To derive Euler equations. To define Euler angles.
2. To solve problem of rotational spinning top.

**CANONICAL FORMALISM**

3. To describe configuration and phase space. To prove Liouville's theorem
4. To define cannonical transformation. To derive generating functions of canonical transformations.
5. To define Poisson brackets. To prove formulas with Poisson brackets.
6. To derive Hamilton-Jacobi equation. To solve Hamilton – Jacobi equation for completely integrable systems. To define action – angle variables

**RELATIVITY**

7. To define covariant and contravariant vector components. To define metric tensor.
8. Using tensor formulation to derive formula for 4-velocity and 4-acceleration. To derive 4-force, energy-moment and to find relation between energy and momentum.
9. To derive relativistic action formula. To define bound energy and mass defect.
10. To define and explain general relativity postulates. To describe non – Euclid geometry. To analyze consequences of general relativity postulates.

**CONTINUUM MECHANICS**

11. To derive equations for transverse motion of a string. To solve wave equation and explain solutions.
12. To explain 3D wave equation, plain and spherical waves.

13. To explain volume and surface forces. To define stress and strain, also elastic modulus. To derive relations between stress and strain.
14. To derive equations of motion for elasticsolid. To find wave velocity in elastic solid.
15. To describe motion of fluid. To derive Bernoulli's theorem. To derive and explain velocity in fluid.

**CONTINUUM DYNAMICS**

16. To derive Sine – Gordon equation.
17. To define and explain variational derivative and variational principle for continuum. To discuss Lagrangian density.
18. To discuss gauge invariance. To state and prove Noether's theorem.
19. To apply field theory formalism on electromagnetic field.

*1.4. Course content*

**Dynamics of rigid bodies:** Translations and rotations. Euler equations. Euler angles. Top. Gyroscope precession.
**Canonical formalism:** Phase space. Canonical variables. Liouville's theorem. Principal function. Hamilton-Jacobi equation. Separation of variables. Action-angle variables. Adiabatic invariants.
**Nonlinearity, nonintegrability and chaos.**
**Special relativity:** Minkowski space. Vectors and tensors in space - time. Kinematics and dynamics of special relativity in space – time. Lagrange formulation. Kinematics of scattering and decay of particles. Gravity and Einstein relativity.
**Continuum mechanics:** Continuum description. Deformations. Stress tensor. Equations of motion for elastic solid bodies. Fluids. Waves.
**Continuum dynamics:** Lagrangian formulation of continuum dynamics. Variational principle. Functional derivative. Maxwell's equations. Noether's theorem. Relativistic fields. Hamiltonian formalism for fields.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other |

| | |
|---|---|
| *1.6. Comments* | |

*1.7. Student's obligations*

- Attendance at all classes and active participation is expected.
- Students should solve, write home works.
- Students should pass two preliminary exams (or written exam) in form of numerical exercises.
- Final oral exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3 | Activity/Participation | 0 | Seminar paper | 0.4 | Experimental work | |
| Written exam | | Oral exam | 2.4 | Essay | | Research | |
| Project | | Sustained knowledge check | 2.2 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students will be evaluated continuously during lectures and on final exam. Maximum percentage during lectures is 50%, and on final exam 50%. On final exam student should have at least 50% point to pass.
Detailed elaboration will be given in executive program.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. Kaliman Z., *Teorijska mehanika*, Filozofski fakultet u Rijeci, Rijeka, 2002.
2. Goldstein H., Poole C., Safko J., Classical Mechanics, Addison-Wesley Publishing Company, USA, 3rd edition, 2000.
3. Taylor J. R., Classical Mechanics, University Science Books, 2005.
4. Wells D. A., *Lagrangian Dynamics*, Schaum Outline Series, McGraw-Hill Book Company, USA, 1967.

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Bradbury T. C., *Theoretical Mechanics*, John Wiley and Sons, New York, 1968.
2. Chow T. L., *Classical Mechanics*, John Wiley and Sons, USA, 1995.
3. Jose J. V., Saletan E. J., *Classical Dynamics: A Contemporary Approach*, Cambridge Univ Pr, 1998.
4. Landau L. D., Lifšic E. M., *Mehanika*, Građevinska knjiga, Beograd, 1961.
5. Supek I., Teorijska fizika i struktura materije, Tisak, Zagreb, 1974.
6. Zimmerman R. L., Olness F. I., *Mathematica for physics*, 2. izdanje, Addison Wesley, USA, 2003.
7. Arnol'd V. I., Mathematical Methods of Classical Mechanics, 2. izdanje, Springer, 1989.
8. Alligood K. T., Sauer T. D., Yorke J. A., Chaos: An Introduction to Dynamical Systems, Springer-Verlag, NewYork,Inc., 1996

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Kaliman Z., *Teorijska mehanika*, Filozofski fakultet u Rijeci, Rijeka, 2002. | 15 | 10-15 |
| Goldstein H., Poole C., Safko J., Classical Mechanics, Addison-Wesley Publishing Company, USA, 3rd edition, 2000 | 15 | 10-15 |
| Taylor J. R., Classical Mechanics, University Science Books, 2005 | 0 | 10-15 |
| Wells D. A., *Lagrangian Dynamics*, Schaum Outline Series, McGraw-Hill Book Company, USA, 1967. | 2 | 10-15 |
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Discussions with the students, questionnaires, achievements on the exams. Regular monitoring students' activities.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Prof. Dijana Dominis Prester | |
| ***Course title*** | COMPUTATIONAL PHYSICS | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 5 |
| | ***Number of hours (L+E+S)*** | 30+15+15 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

Learning of methods for solving physical problems using numerical methods. Learing and application of different optimization methods. Training programming skills.

### 1.2. Course enrolment requirements

General Physics Courses. Basics of computer programming is desired, but not a strict requirement.

### 1.3. Expected course learning outcomes

The course is focused on practical applications of programming in FORTRAN for solving problems in physics. The students will obtains the programming skills suitable for applications on a wide range of problems.

After successfully acomplished course, the student will be able to:

- describe numerical methods in physics and mathematics
- write simple computer codes using simulations
- apply existing software packages for simulations, animation and visualization
- define and describe optimisation
- differentiate optimisation methods
- describe genetic algorithms
- write a computer code which optimizes a non-liner problem using a chosen optimisation method

### 1.4. Course content

Basics of FORTRAN. Numerical methods in physics and mathematics. Monte Carlo simulations. Animation and visualisation of computer simulations. Numerical optimization methods of solving multidimenzional physical problems. Simplex algorithm. Neural networks. Genetic algorithms. Simulations in high-energy physics and astrophysics. Computationl analysis of simulated and measured physical data.

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐other |

| | |
|---|---|
| ***1.6. Comments*** | The course will be subject to changes and continuous improvements, depending on the availability of new software and hardware. |

***1.7. Student's obligations***

Course attendance, homework, programming, individual project.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance and activity | 2,0 | Portfolio | | Seminar paper | | Experimental work | |
| Written exam | 1,7 | Oral exam | 0,3 | Essay | | Research | |
| Project | | Sustained knowledge check | 0,8 | Report | | Practice | 1,2 |
| | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

Manner of knowledge checking: class participation, homework, project, written and oral exam. Student's work will be evaluated during the semester, and during the final exam.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

1. Course Web page
2. H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods, Addison-Wesley, Reading, Massachusetts
3. M. Metcalf, Fortran 90 Tutorial, CERN

***1.11. Optional / additional reading (at the time of proposing study programme)***

1. W. H. Press, B. P. Flannery, S. A. Teukolsky, W. T. Vetterling, Numerical Recipes, Cambridge University Press 2. D. Frenkel, B. Smit, Understanding Molecular Simulation (from algorithms to applications), Academic Press
3. M. P. Allen, D. J. Tildesley, Computer Simulation of Liquids, Clarendon Press, Oxford
4. D. C. Rapaport, The Art of Molecular Dynamics Simulation, Cambridge University Press
5. S. E. Koonin, Computational Physics, Benjamin Cummings
6. D. W. Heermann, Computer Simulation Methods in Theoretical Physics, Springer-Verlag, Berlin

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | |
| | | |
| | | |
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| | | |
| | | |
| | | |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

Interaction with students and student-faculty team work on quality of teaching process. Anonymous questionnaires on quality of teaching. Flexible adaptation of teaching to interests and needs of students.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Assistant Professor dr.sc. Robert Peter | |
| *Course title* | DATA ANALYSIS | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 1. year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 4 |
| | *Number of hours (L+E+S)* | 30+30+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The main objective of the course is to introduce students to essential statistical methods and their application to analysis of physical measurements. In particular, students will be introduced to error analysis which forms a basis for work in a laboratory. Additionally, the elementary probability theory is necessary to comprehend the basic principles of statistical physics and quantum mechanics.

### *1.2. Course enrolment requirements*

There are no prerequisites for the course enrolment. The course starts in the 2nd semester of 1st undergraduate year so that only high-school mathematics and basics of calculus will be required for the most part the theory. Knowledge of elementary probability theory and statistics from high-school is welcome.

### *1.3. Expected course learning outcomes*

After passing the exam, student will be able:

1. to plot the measured data and calculate the basic statistics of samples;
2. to define the theoretical (a priori) and empirical probability (a posteriori) and to know Kolmogorov axioms;
3. to calculate elementary examples in probability using combinatorial counting and to use Bayes theorem
4. to know the basic properties of discrete distributions (binomial, Poisson and geometric distributions) and use them in physical problems;
5. to know the basic properties of continuous distributions (normal, exponential, Lorentz and Hi-squared distributions) and use them in physical problems;
6. to calculate the dispersion parameters of data and coefficient of linear correlation;
7. to know the central limit theorem and its meaning;
8. to use the method of least squares to fit linear or a nonlinear function on measured data;
9. to know and use basic parameter estimators and to define the maximum likelihood function;
10. to apply statistical tests (Hi-squared, Kolmogorov, student t-test) for comparison of empirical and theoretical frequencies.

### *1.4. Course content*

*Introduction to Error Analysis*: physical measurement and errors, types and estimations of errors, significant figures, statistical analysis.

*Descriptive Statistics*: types of data, describing data on a single variable: graphical methods (histograms and frequency distributions), measures of central tendency and dispersion; describing data from more than one variable: correlation.
*Elementary Probability Theory*: random experiments, sample space, combinatorics, conditional probability and Bayes' theorem, Bernoulli's scheme, random variables, mathematical expectation and variance, the axiomatic approach to probability theory.
*Theoretical Distributions:* discrete distributions (binomial, Poisson and geometric distributions), continuous distributions (normal, exponential, Lorentz and Hi-squared distributions)
*Statistical Estimation Theory*: properties of estimators, estimating the mathematical expectation and variance, the method of maximum likelihood, estimator parameters of normal distribution, the method of moments.
*The Method of Least Squares:* the straight line fit, the Hi-squared distribution, the non-linear fit, the examples are made in the software package Mathematica
*Statistical Decision Theory*: hypothesis testing, interpretation of the experiment, the accuracy of the adjustment of theoretical distribution to empirical data, Neyman-Pearson, Hi-squared, Kolmogorov, student t-test

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |

| | |
|---|---|
| *1.6. Comments* | |

*1.7. Student's obligations*

Students are obliged:

- to attend regularly and to participate actively in lectures and exercises;
- to do their homework independently;
- to pass two midterm exams;
- to pass final oral exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2,0 | Activity/Participation | 0,2 | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 0,8 | Essay | | Research | |
| Project | | Sustained knowledge check | 1,0 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Student will be evaluated and assessed during the course and final exam. Maximum total percentage which student can achieve during the lessons is 60%, while the final exam (oral) provides 40% at the best.
Detailed elaboration of ways of monitoring and evaluation of students' work will be displayed in the Working Plan.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. Barlow R., Statistics - *A Guide to the Use of Statistical Methods in the Physical Sciences*, John Wiley, New York, 1989.
2. Taylor, J. R., *An Introduction to Error Analysis*, 2nd ed., University Science Books, Sausalito, 1997.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Bevington P. R., Robinson K. D., *Data reduction and Error Analysis for Physical Scineces*, 3rd ed., Mcgraw-Hill, New York, 2003.
Chung K. L., Aitsahilia F., *Elementary Probability Theory*, 4th ed., Springer USA, New York, 2003.
Drosg M., *Dealing with Uncertainties - A Guide to Error Analysis*, 2ed.,Springer, Berlin, 2009.
Fornasini P., *The Uncertainty in Physical Measurements An Introduction to Data Analysis in the Physics Laboratory*, Springer, Berlin, 2008.
Kirkup L., Frenkel R. B., *An Introduction to Uncertainty in Measurement Using the Gum*, Cambridge University Press, Cambridge, 2006.
Lyons L., *A practical guide to data analysis for physical science students*, Cambridge University Press, Cambridge, 1991.
Meyer S. L., *Data Analysis for Scientists and Engineers*, John Wiley, New York, 1975.
Pauše Ž., *Uvod u matematičku statistiku*, Školska knjiga, Zagreb, 1993.
Pavlić I., *Statistička teorija i primjena*, Tehnička knjiga, Zagreb, 1988.
Rabinovich S. G., *Measurement Errors and Uncertainties - Theory and Practice*, 3rd ed., Springer, Berlin, 2005.
Ross S. M., *Introduction to Probability Models*, 10th ed., Academic Press, New York, 2009.
Spiegel M. R., *Schaum's Outline of Probability and Statistics*, 3rd ed., Mcgraw-Hill, New York, 2009.
Spiegel M. R., *Schaum's Outline of Statistics*, 4th ed., Mcgraw-Hill, New York, 2008.
Stanford J. L., *Statistical Methods for Physical Science*, Academic Press, San Diego, 1994.

WWW
http://www.upscale.utoronto.ca/PVB/Harrison/ErrorAnalysis/
http://documents.wolfram.com/applications/eda/
http://phys.columbia.edu/~tutorial/

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Barlow R., Statistics - *A Guide to the Use of Statistical Methods in the Physical Sciences*, John Wiley, New York, 1989. | 1 | 10 |
| Taylor, J. R., *An Introduction to Error Analysis*, 2nd ed., University Science Books, Sausalito, 1997. | 1 | 10 |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Regular monitoring of the student's activity and attitude towards work. In the last week of classes, anonymous surveys will be conducted in which students will evaluate the quality of teaching. At the end of each semester student' success in examinations will be analyzed.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Prof. dr. sc. Predrag Dominis Prester | |
| *Course title* | Electrodynamics | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 3rd | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 12 |
| | *Number of hours (L+E+S)* | 45+45+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

- Giving the basic knowledge of classical electrodynamics and special theory of relativity
- Connecting the exact theoretical results with the relevant objects from electricity and magnetism that students have learned in earlier courses
- Developing and practicing advanced mathematical skills and tools for solving problems based on partial differential equations

### *1.2. Course enrolment requirements*

**Physics I-III, Mathematical methods in physics I and II.**

### *1.3. Expected course learning outcomes*

- Understanding the idea how simple and basic equations for the electromagnetic field, with the help of mathematical methods, can explain complex physical phenomena.
- Understanding the significance of the exact definition of physical quantities, their calculation and connection to experiments.
- Ability to autonomously set and solve problems not only in the realm of electrodynamics, but also for more general systems described by differential equations.

### *1.4. Course content*

1. **Electrostatics**
Coulomb law. Electric field. Scalar potential. Equations of electrostatics. Properties and techniques of solving Poisson and Laplace differential equations. Conductors and capacitors. Energy. Multipole expansion. Electrostatics in media. Boundary conditions.
2. **Magnetostatics**
Electric current. Continuity equation. Magnetic field and force. Vector potential. Equations of magnetostatics. Methods of solving equations. Magnetostatics in media. Boundary conditions.
3. **Maxwell equations**
Faraday law of induction. Energy of magnetic field. Maxwell equations. Potentials. Gauge transformations. Poynting theorem. Conservation laws. Electrodynamics in the media. Integral formulation - retarded and advanced potentials. Field of a point charge in an arbitrary motion.
4. **Electromagnetic waves**
Wave equation. Plane wave solutions in vacuum and dielectrics. Polarisation. Energy and momentum of EM waves. Refraction of EM waves. EM waves in conductors. Dispersion and absorption. Wave packets.
5. **Radiation**
Dipole approximation. Radiation of a point charge. Bremsstrahlung and cyclotron radiation. Radiation reaction force.

6. **Special relativity**
Basic postulates. Lorentz transformations. Geometry of special relativity. Kinematics and dynamics. Lorentz tensors. Lorentz transformations of fields, charge density and currents. Covariant formulation of electrodynamics.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |

*1.6. Comments*

*1.7. Student's obligations*

**Active participation in the classroom, doing home assignments and periodic tests, passing the final exam.**

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3.5 | Activity/Participation | 0.5 | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 3 | Essay | | Research | |
| Project | | Sustained knowledge check | 5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students will be evaluated and valued continuously during the course, through home assignments and periodic tests, and at the final exam. Activities during the course bring maximally 70% of the total mark.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. Griffiths D. J., *Introduction to Electrodynamics*, 3. ed. (Prentice-Hall, New Jersey, 1999.) or newer
2. Labinac V., Solved Problems in Electrostatics and Magnetostatics (Univ. of Rijeka, 2003.)

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Jackson J. D., *Classical Electrodynamics*, 3. ed. (John Wiley, New York, 1999.)
2. Nayfeh M. H., Brussel M. K., *Electricity and Magnetism,* John Wiley and Sons, 1985
3. Zangwill A., *Modern Electrodynamics*
4. Wegner F., http://www.tphys.uni-heidelberg.de/~wegner/e.dyn/

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Griffiths D. J., *Introduction to Electrodynamics* | 3 | 15 |
| | | |
| | | |
| | | |
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

**Consultations, anonymous student questionnaires through the ISVU system, discussions after the final exam.**

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Assistant Professor dr. sc. Diana Mance | |
| ***Course title*** | Environmental physics | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3. | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 5 |
| | ***Number of hours (L+E+S)*** | 20+10+10 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Students in this course should acquire basic knowledge of environmental physics, which includes basic knowledge of the physics of the atmosphere, hydrosphere and soil, as well as the role of this discipline in ecology and sustainable use of natural resources.

### *1.2. Course enrolment requirements*

/

### *1.3. Expected course learning outcomes*

Students in this course should:
- gain insight into the subject of environmental physics research;
- know the basic parameters of the physics of the atmosphere, hydrosphere and soil;
- get acquainted with the basics of radioactivity in the environment;
- get acquainted with basic data analysis in environmental science with the use of appropriate computer programs; and
- get to know the role of physics in environmental planning and sustainable use of natural resources.

### *1.4. Course content*

- Fundamentals of atmospheric physics
- Solar radiation and planetary temperature
- Fundamentals of hydrosphere physics
- Fundamentals of wind physics
- Fundamentals of soil physics
- Energy and environment
- Sound and noise
- Radioactive and stable isotopes in the environment
- Environmental pollution
- Data processing methods in environmental science

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### *1.7. Student's obligations*

Active participation during the teaching process.

Writing and presentation of seminars.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.5 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
| Written exam | | Oral exam | 2 | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

Students work will be evaluated and assessed during the semester and final exam. Total number of credits a student can achieve during the semester is 70, while during the final examination can achieve 30 points. The detailed working out ways of monitoring and evaluation of student's work will appear in the implementation plan of the course.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

1. Mason N., Hughes P. 2001. Introduction to Environmental Physics: Planet Earth, Life and Climate, Taylor and Francis
2. Monteith J.L., Unsworth M.H. 2014. Principles of Environmental Physics, Elsevier
3. Crawley M.J., 2012. The R Book, Wiley

***1.11. Optional / additional reading (at the time of proposing study programme)***

1. Hillel, D., 2004. Introduction to environmental soil physics. Elsevier Academic Press, Amsterdam
2. Mook, W.G. (Ur), 2001. Environmental isotopes in the hydrological cycle: Principles and applications. IAEA, Paris, 570 pp (http://www-naweb.iaea.org/napc/ih/IHS_resources_publication_hydroCycle_en.html)

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

Feedback on course quality and achievements is obtained from permanent communication to students and on consultation hours. Student's progress and adopted level of integrated thinking is being followed during the course.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Professor Rajka Jurdana-Šepić | |
| *Course title* | FUNDAMENTALS OF ASTRONOMY AND ASTROPHYSICS | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 3rd | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 4 |
| | *Number of hours (L+E+S)* | 30+0+15 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

Introduce the students to general astronomy, its basic methods and instruments, with an emphasis on the recent development in astrophysical research. The course should encourage student's interest for the scientific and technical achievements of modern astrophysical research

*1.2. Course enrolment requirements*

No formal prerequisites. Knowledge of general physics is assumed.

*1.3. Expected course learning outcomes*

After the course, students should be able to:
1. describe the electromagnetic and corpuscular radiation in the universe and the possibility of its detection, define the apparent and absolute magnitude, luminosity and radiation intensity,
2. analyse working principles, function and elements of telescopes, interferometers and detectors used in optical, radio-, IR, UV and γ- spectral regions and describe photometrical systems,
3. define the units and describe the methods for measurements of astronomical distances
4. define the coordinate systems intended to specify the positions on the celestial sphere, describe the phenomena related to the rotation and revolution of Earth (apparent planet motion, eclipses, sidereal and synodic periods, precession),
5. classify the planets according to their physical properties and describe the methods for their study, describe basic characteristics, dynamic properties and elements of orbits of the solar system bodies (planets, moons, asteroids, comets) and formation of the solar system,
6. list the general properties of the Sun and its atmosphere, analyse the solar activity and its related phenomena using the theory of solar magnetism,
7. classify the stars according to their spectra, determine physical properties of the stars and explain the Hertzsprung Russell diagram,
8. derive the basic relations of the theory of stellar structure and describe pulsation mechanism of variable stars,
9. analyse internal structure, energy sources and transfer in stars and apply it to explanation of the evolution of stars, stellar associations and clusters,
10. describe the morphologic classification of galaxies, describe the general features and structure of the Milky way, spiral and eliptic galaxies and galaxy clusters,
11. describe the Big bang theory, microwave background radiation and analyse observations of the expanding universe.

*1.4. Course content*

Astronomical distances, units and methods of measurement. Instruments. Methods (spectroscopy, photometry). Solar system: dynamic and physical characteristics. Sun. stars: spectral classification, HR diagram. Stellar structure and evolution. Interstellar matter. Milky way. Extragalactic systems.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☐ exercises<br>☒ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |

*1.6. Comments*

*1.7. Student's obligations*

Course attendance, seminar paper and its oral presentation, verification of the aquired knowledge through written tests and to pass the final course exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1,5 | Activity/Participation | 0,3 | Seminar paper | 0,5 | Experimental work | |
| Written exam | 1 | Oral exam | 0,7 | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

The students' work is being permanently assessed and evaluated through written tests. The total number of credits a student can achieve during the course (reviewed activities specified in the table), refer to the points earned on the final exam as 70:30.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

B.W.Carroll, D.A.Ostlie: An introduction to modern astrophysics, Addison-Wesley, 2007
V. Vujnović: Astronomija I, Školska knjiga, Zagreb 1989.
V. Vujnović: Astronomija II, Školska knjiga, Zagreb 1990.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Hoyle F.: Astronomija, Marjan tisak, Split, 2005.
D. Prialnik: An introduction to the theory of stellar structure and evolution, Cambridge University Press, 2009.
A.Unsold, B.Baschek: The new cosmos, Springer, 1991.
M. Harwit: Astrophysical concepts, Springer, 1988.
E. Boehm-Vitensee: Introduction to stellar astrophysics, Cambridge University Press, 1989.
H. Scheffler, H. Elsasser: Physics of the galaxy and interstellar matter, Springer, 1987.
P. Lena: Observational astrophysics, Springer, 1988.
H. Karttunen, P. Kroger, M. Pontanen, K.J. Donner: Fundamental astronomy, Springer, 1994.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| B.W.Carroll, D.A.Ostlie: An introduction to modern astrophysics, Addison-Wesley, 2007 | 4 | 8 |
| V. Vujnović: Astronomija I, Školska knjiga, Zagreb 1989 | 5 | 8 |
| V. Vujnović: Astronomija II, Školska knjiga, Zagreb 1990. | 3 | 8 |

| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
|---|
| Continuous assessment of students' work (written tests and discussions during the seminars).<br>Questionnaire at the end of the course designed to evaluate quality of course program, lectures and lecture materials, teaching methods and interaction with students. After oral exam student is asked to comment course program and to give suggestions about lectures and lecture materials, teaching methods and possible individual difficulties met during the learning process. |

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Velimir Labinac | |
| ***Course title*** | FUNDAMENTALS OF COMPUTER SCIENCE | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 1. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 3 |
| | ***Number of hours (L+E+S)*** | 15 + 15 + 0 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

To acquaint the student with basic concepts of computer science, to clarify how a computer works and to practice working in Microsoft Windows and OS Linux and software packages Microsoft Office, Wolfram Mathematica, QtiPlot and others, necessary for the completion of the final and graduate work. The course is designed for students who feel they have not earned a basic computer science degree in high school. Classes are taught on the computer as a series of guided assignments. Before each assignment, the teacher provides a brief theory and instructions for completing the assignment.

### 1.2. Course enrolment requirements

Students can enrol this course at no additional requirements.

### 1.3. Expected course learning outcomes

After completing the course and passing the exam, students are expected to be able to:

- create text with formulas, tables and figures in a Microsoft Word text editor;
- create text with simpler formulas, tables and figures in a Latex text editor;
- create a data group file in Microsoft Excel spreadsheets, and draw a graph in the same software package at the level required for physics practitioners;
- create a simple PowerPoint presentation;
- create a graph of a simple function in QtiPlot
- perform simple tasks on Windows and Linux (copying and deleting files, working with Internet browsers, using FTP, command work, …).

### 1.4. Course content

Working in Microsoft Windows. Write text, equations and tables in Microsoft Word. Templates in Microsoft Word. PowerPoint presentations. Computing with a data group and drawing graphs in Excel. Draw graphs in QtiPlot software package. Writing text and simpler formulas in Latex (Miktex distribution). The basics of working in Linux. Creating simple drawings and calculations in the Wolfram Mathematica software package.

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☒ practicum |
| ***1.6. Comments*** | | |

### 1.7. Student's obligations

Students are obligated:

- to attend regularly and to participate actively in lectures and exercises;
- to do practicum exercises and their homework independently;
- to make a brief seminar paper with PowerPoint presentation;
- to pass preliminary exam and final oral exam.

### 1.8. Evaluation of student's work

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 0.8 | Activity/Participation | 0.2 | Seminar paper | 0.5 | Experimental work | |
| Written exam | 1.0 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 0.3 | Report | 0.2 | Practice | |
| Portfolio | | | | | | | |

### 1.9. Assessment and evaluation of student's work during classes and on final exam

Student will be evaluated and assessed during the course and final exam. Maximum total percentage which student can achieve during the lessons is 70%, while the final exam (written and oral) provides 30% at best.
Detailed elaboration of ways of monitoring and evaluation of students' work will be displayed in the Working Plan!

### 1.10. Assigned reading (at the time of the submission of study programme proposal)

Brookshear J. G., *Computer Science – An Overview*, 13th ed., Pearson Education, Boston, 2019.

### 1.11. Optional / additional reading (at the time of proposing study programme)

B. Forouzan, F. Mosharraf, *Foundations of Computer Scinece*, Cengage Learning, London, 2008.
Budin L., *Informatika 1*, Element, Zagreb, 2002.
Dale N., Lewis J., *Computer Science Illuminated*, Jones and Barlett, Sudbury, 2002.
Grundler D., Blagojević L., *Informatika 1*, Školska knjiga, Zagreb, 2007.
Grundler D., *Kako radi računalo*, PRO-MIL, Varaždin, 2004.
Gvozdanović T., *e-Citizen*, PRO-MIL, Varaždin, 2005.
Reynolds C., Tymann P., *Principles of Computer Science*, McGraw-Hill, New York, 2008.
Tyson H., *Word 2007 Bible*, Wiley Publishing, New York, 2007.
Walkenbach J., *Excel 2007 Bible*, Wiley Publishing, New York, 2007.
Walkenbach J., Tyson H, *Office 2007 Bible*, Wiley Publishing, New York, 2007.

WWW
http://academicearth.org/
http://web.math.hr/nastava/rp1p/
http://www.fpz.hr/~goldh/racun200910/

### 1.12. Number of assigned reading copies with regard to the number of students currently attending the course

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Brookshear J. G., *Computer Science – An Overview*, 13th ed., Pearson Education, Boston, 2019. | 1 | 10-15 |
| | | |

### 1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences

Regular monitoring of the student's activity and attitude towards work. In the last week of classes, anonymous surveys will be conducted in which students will evaluate the quality of teaching. At the end of each semester (1 March and 30 September of the current academic year) student' success in examinations will be analyzed.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Assoc. Prof. Gabriela Ambrožić | |
| ***Course title*** | General Chemistry | |
| ***Study programme*** | Undergraduate Study Programme in Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3rd | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 5 |
| | ***Number of hours (L+E+S)*** | 30 L + 0 E + 15 S |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

Mastering the basics of chemistry.

### 1.2. Course enrolment requirements

Achieved enrollment for the undergraduate programme.

### 1.3. Expected course learning outcomes

After passing the exam, students will be able to:
- explain the electronic structure of atoms and the position of elements in the periodic table;
- explain the properties of elements based on electronic configuration;
- define the types of bonds in compounds and on that basis predict their chemical properties;
- explain the properties of the substance depending on the physical state;
- distinguish and explain protolytic, redox and complex reactions;
- define the rate of a chemical reaction and explain the influence of various factors on the rate of chemical reactions;
- distinguish between weak and strong electrolytes;
- explain the chemical equilibrium in weak electrolyte solutions.

### 1.4. Course content

- Composition and structure of matter
- Atoms, molecules and ions
- Chemical reactions
- Stoichiometry
- Quantum-mechanical model of atoms
- Periodic properties of the elements, electron configuration, orbitals
- Intramolecular chemical bonds, Lewis model, ionic bond, covalent bond, metallic bond.
- Chemical kinetics
- Chemical equilibrium
- Chemical thermodynamics
- Electrochemistry
- Radioactivity and nuclear chemistry
- Chemistry of non-metals (basics)
- Metals and metallurgy (basics)
- Transition metals and coordination compounds (basics)

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | X lectures<br>X seminars and workshops<br>☐ exercises | X individual assignment<br>☐ multimedia and network<br>☐ laboratories |

| | | |
|---|---|---|
| | X long distance education<br>☐ fieldwork | ☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

***1.7. Student's obligations***

Attending lectures and seminars, solving homework and taking exams.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.5 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1.5 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 2.0 | Report | | Practice | |
| Portfolio | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

The grade from the course Chemistry I provides complete information about the performance of the candidate, and includes the results of the assessment through the conducted lectures and the final exam.
Continuous teaching consists of two tests (stoichiometry and theory) and regular course attendance.
The seminar consists of student solving tasks in stoichiometry.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

1. Filipović, I; Lipanović, S.: Opća i anorganska kemija I, Školska knjiga, Zagreb, 1991
2. Sikirica M.: Stehiometrija, Školska knjiga, Zagreb.

***1.11. Optional / additional reading (at the time of proposing study programme)***

Nivaldo J. Tro, Chemistry–the molecular approach, 3th Edition, Pearson Education Inc., 2014

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | |
| | | |
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| | | |
| | | |
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| | | |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

Constant interaction with students and stimulation of work students-teacher to promote the quality of teaching. Flexible adaptation of teaching to the interests and needs of students. Transience analysis.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Assistant Professor dr.sc. Iva Šarić | |
| *Course title* | LABORATORY PROJECT | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Elective | |
| *Year* | 3. year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 3 |
| | *Number of hours (L+E+S)* | 0+0+30 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

The prime aims of this subject are to introduce to the students the basic concepts of the experimental research in real, laboratory environment and to show them how to apply the knowledge gained during their undergraduate studies to solve some real physical problems.

*1.2. Course enrolment requirements*

No formal prerequisites. Knowledge of general and theoretical physics according to the study programme is assumed

*1.3. Expected course learning outcomes*

- experimental technique and apparatus avalable at the Department of Physics
- ability to aplay the aquired knowledge of the experimental techniques in solving real phisical problem
- connect theoretical models with the experimental results conducted
- describe the research project (experiment and the appropriate tehoretical model)
- analyse experimental results, conduct statistical analysis and display the experimental results

*1.4. Course content*

Students will undertake one of the experimental laboratory projects offered by the experimental laboratories of the Department of Physics.

| *1.5. Teaching methods* | | |
|---|---|---|
| | ☐ lectures | ☒ individual assignment |
| | ☒ seminars and workshops | ☐ multimedia and network |
| | ☐ exercises | ☒ laboratories |
| | ☐ long distance education | ☒ mentorship |
| | ☐ fieldwork | ☐ other |

| *1.6. Comments* | |
|---|---|

*1.7. Student's obligations*

By the end of the semester, the students are required to present a short talk on one of the following subjects: description of the research project, description of the experimental technique and apparatus or description of measurements and data analysis.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.0 | Activity/Participation | | Seminar paper | 1.0 | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | 1.0 |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

The student's work will be evaluated during the work in the laboratory and through the presentation of seminar

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Literature will be given according to the choice of the project.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Literature will be given according to the choice of the project.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Laboratory work includes mentorship and consulting work with the student, monitoring the student's activities and attitude towards work, which leads to gaining feedback on performance and progress.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Janka Petravić | |
| *Course title* | Mathematical models in natural sciences and humanities | |
| *Study programme* | Undergraduate course Physics | |
| *Course status* | Elective | |
| *Year* | 2nd or 3rd year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 5 |
| | *Number of hours (L+E+S)* | 30+15+15 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

Introduction to the history of mathematical modelling in natural sciences and humanities, with examples of simple mathematical models in biology, medicine, ecology, public health and climate science. Applications of the most important methods from mathematics in physics in economics and humanities. Critical evaluation of models in numerical simulations.

*1.2. Course enrolment requirements*

First year general physics and mathematics courses (calculus and linear algebra) and programming experience are desirable but by no means necessary. Solid knowledge of high school physics and mathematics could be sufficient with a small additional effort.

*1.3. Expected course learning outcomes*

After completing the final exam, the student will be able to:

- Explain important models that influenced the development of modelling in natural sciences and humanities.
- Apply the fundamental methods in deterministic and stochastic modelling
- Perform independent literature search.
- Understand the aims, methods and results of scientific studies using mathematical modelling in other sciences
- Critically evaluate the applicability and the limitations of the model.
- Write simple code in Excel and python independently.

*1.4. Course content*

History of modelling in natural sciences and humanities. Control theory and feedback. Modelling in biology: ecology (predator-prey models), within-host models of infectious disease (standard model of viral infection) and applications to computer viruses, epidemiological models (SIS, SIR), evolutionary models, applications in public health. First models of climate change (black and white daisies). Stochastic models based on diffusion (searching for food and Lévy flight). Introduction to game theory. Application of evolutionary models and game theory to humanities: evolution of language, spreading of gossip, selfishness theory and the development of cooperation – application to economics, the evolution of behavioural norms between sexes.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☒ tutorials<br>☒ long distance education | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship |

| | | |
|---|---|---|
| | ☐ fieldwork | ☐ other |

| | |
|---|---|
| *1.6. Comments* | The programme can be modified according to students' interests, and could be also offered to students in other fields of study, for example biotechnology or humanities. |

*1.7. Student's obligations*

Attendance of lectures and tutorials. Active participation in coursework. Completing homework. Preparing a seminar. Active and critical participation in students' seminars.

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
| Written exam | 1 | Oral exam | 1 | Essay | | Research | 0.5 |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students' efforts will be assessed during the course and in the final exam. Assessment methods: seminar preparation, active participation in other students' seminars, homework and projects during the semester, tests and quizzes, writing computer code.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Because of the breadth and specificity of the course, there is no unique course manual. In addition lectures, students will have access to lecture notes and journal articles on Merlin.

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Martin Nowak: Evolutionary Dynamics – Exploring the Equations of Life. 2006. Harvard University Press
2. Thomas C. Schelling: Micromotives and Macrobehavior. 1978. W.W.Norton & Co. New York
3. Roy M. Anderson and Robert M. May: Infectious Diseases of Humans: Dynamics and Control, 1991. Oxford University Press, Oxford
4. Martin Nowak and Robert M. May: Virus Dynamics: Mathematical Principles of Immunology and Virology. 2000. Oxford University Press.
5. Alan S. Perelson and Gerard Weisbuch, Immunology for Physicists. Rev. Mod. Phys.1997. **69**: p.1219.
6. Jared Diamond: The Third Chimpanzee, 2014. Seven Stories Press, New York.
7. James E. Lovelock: Gaia: a new look at life on earth, 1979, Oxford University Press, Oxford
8. Clio Creswell: Mathematics and Sex. 2003. Allen and Unwin.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Regular monitoring of students' participation in lectures and tutorials, with feedback about perceived progress and achievement. At the start of the course, a questionnaire about each student's expectations from the course. Final anonymous questionnaire about the quality of the course. After the final exam, the teacher will ask feedback about the goals reached in the course: the teaching method, difficulties in understanding parts of the curriculum and suggestions for improvement.

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| **Basic description** | | |
|---|---|---|
| ***Course coordinator*** | Prof. Mladen Petravić | |
| ***Course title*** | MEASUREMENTS IN PHYSICS | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 5 |
| | ***Number of hours (L+E+S)*** | 30+15+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The main goal of this course is to show to students the importance of experiments and measurements of physical quantities in development, testing and verifying of theoretical models. The course includes the basic concepts of Metrology and measurements methods from antics to modern time. Key experiments preceding development of fundamental physical laws or concepts, such as Newton laws, Maxwell equations or Bohr's model of atom. Examples of planning and design of experiments are given by the discovery of electron, proton, neutron and positron and measurements of their properties and by examples of measurements of mechanical, electrical, magnetic and optical properties of materials. Several modern analytical techniques using beams of atomic particles for the characterisation of materials, available in several Laboratories in Croatia, are introduced.

### *1.2. Course enrolment requirements*

Basic concepts in scientific measurements
Measurements methods from Antics to modern time
Key experiments preceding development of fundamental physical laws or concepts
Discovery of electron, proton, neutron and positron and measurements of their properties
Beams of atomic particles for the characterisation of materials
Examples of measurements of mechanical, electrical, magnetic and optical properties of materials

### *1.3. Expected course learning outcomes*

Develop understanding and interest for measurements; gain knowledge about key experiments in history of physics; recognise the key role of experiments and measurements in discovery of physical phenomena and the creation and verification of a physical theory.

### *1.4. Course content*

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### *1.7. Student's obligations*

Regular attendance of classes
Presentation of one seminar paper

Pass two written exams with numerical problems
Pass an oral exam

### _1.8. Evaluation of student's work_

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | 1 | Experimental work | |
| Written exam | 1 | Oral exam | 1 | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

### _1.9. Assessment and evaluation of student's work during classes and on final exam_

Active participation of students in classes and project work, with presentations of seminars. Acquirement, analysis and synthesis of competences in topics being taught via readings of bibliographical references. Discussion of these topics on lectures and exercises (1 ECTS) as well as via written and oral presentations, partial and final exams (4 ECTS).

### _1.10. Assigned reading (at the time of the submission of study programme proposal)_

1. A. S. Morris, Measurement & Instrumentation Principles, Butterwort-Heinemann, Oxford, (2001).

### _1.11. Optional / additional reading (at the time of proposing study programme)_

1. Springer Handbook of Materials Measurement Methods, Springer, Berlin, (2006).

### _1.12. Number of assigned reading copies with regard to the number of students currently attending the course_

| _Title_ | _Number of copies_ | _Number of students_ |
|---|---|---|
| 1.A. S. Morris, Measurement & Instrumentation Principles, Butterwort-Heinemann, Oxford, (2001). | 1 | 3 |

### _1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences_

Interaction with students and student-faculty team work on quality of teaching process. Anonymous questionnaires on quality of teaching. Flexible adaptation of teaching to interests and needs of students. Analysis of passing rates.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Professor Rajka Jurdana-Šepić | |
| *Course title* | METHODOLOGY OF ELABORATING PROFESSIONAL AND SCIENTIFIC PAPERS | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 3rd | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 1 |
| | *Number of hours (L+E+S)* | 15+0+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The primary objective of the course is to teach students to solve problems independently, to deal with theoretical and practical research problems, which do not have to be original. To teach students to write professional thesis, and give them introducion to the principles of professional thesis writing and train them to write structured thesis

### *1.2. Course enrolment requirements*

Admission to the third year of undergraduate studies in physics

### *1.3. Expected course learning outcomes*

At the end of the course, students will be able to:
1. independently write a professional/research paper, define aims and goals of the research study,
2. independently review and use the scientific literature and other sources of knowledge,
3. understand the difference between concept and synopsis of the professional/research paper and apply it in writing,
4. apply, organise and extend the knowledge acquired during the studies on specific topic (procedural knowledge),
5. correctly use metrology of legal standard units, mathematical apparatus and mathematical terminology,
6. distinguish technical terminology from the standard language, use scientific language correctly and communicate scientifically,
7. correctly and clearly organise and show data and results in figures and tables, as well as illustrations (tables, graphs, functions, charts, diagrams, drawings, photographs, images, figures),
8. write scientific text with the proper grammar, punctuations and spelling, and properly cite references,

### *1.4. Course content*

Introduction to the official rules for bachelor and diploma thesis. Collecting and studying the literature. Writing synopsis of the topic and concept of the scientific/professional paper. Articulation and writing of professional thesis and scientific paper. The structure of the professional and scientific paper. Structure of the thesis and paper. Cohesion and unity of the text. Preparation of illustrations. Citations and bibliography. Writing and editing the final paper/thesis. Metrological correctness. Spelling, punctuations, grammar and style (clarity, simplicity and conciseness). Content of the cover and inside pages of the thesis.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☐ exercises<br>☒ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other |
| *1.6. Comments* | Classes are taught in the teaching space in the library with the technical assistance contractor seminars. | |

*1.7. Student's obligations*

Class attendance is mandatory. Student has to choose field and topic of his seminar/talk in the area of his bachelor thesis. He has to collect and study literature, write concept of his scientific paper and submit it for supervision, as well as to define main parts and structure of his thesis. Students are continuously supervised, especially to appropriately use metrological terminology and to follow main principles of writing a professional/scientific paper.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Class attendance is mandatory and regularly supervised.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. R. Zelenika: Metodologija i tehnologija izrade znanstvenog i stručnog djela, Ekonomski fakultet Sveučilišta u Rijeci, Rijeka. 2000.
2. K. Ražnjević: Jedinice Međunarodnog sustava (SI) i mjerne jedinice u Hrvatskoj, Axiom, Zagreb, 1997.
3. web sources
http://web.efzg.hr/dok/dokumenti/efzg_diplomski_seminarski_upute.pdf
http://www.vus-ck.hr/docs/Od_teme_do_diplomskog_rada.doc

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Dictionary of the Croatian language
2. Dictionary of foreign words
3. Spelling Croatian Language

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| R. Zelenika: Metodologija i tehnologija izrade znanstvenog i stručnog djela, Ekonomski fakultet Sveučilišta u Rijeci, Rijeka. 2000. | 2 | 5 |
| K. Ražnjević: Jedinice Međunarodnog sustava (SI) i mjerne jedinice u Hrvatskoj, Axiom, Zagreb, 1997. | 3 | 5 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Questionnaire at the end of the course designed to evaluate quality of course program, lectures and lecture materials, teaching methods and interaction with students.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Professor Rajka Jurdana-Šepić | |
| *Course title* | METHODOLOGY OF WRITING AND PRESENTING PROFESSIONAL AND SCIENTIFIC WORK | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 3rd | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 4 |
| | *Number of hours (L+E+S)* | 20+0+40 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

- to teach students to solve problems independently, to deal with theoretical and practical research problems, which do not have to be original,
- to teach students to write a professional thesis and paper, and to give them an introduction to the principles of professional thesis/paper writing,
- to train students to write a structured thesis
- to train students for presenting scientific research results in seminars and conference talks
- to prepare students for the writing and public defence of the bachelor and master thesis.

*1.2. Course enrolment requirements*

Admission to the third year of undergraduate studies in physics. Basic computer skills.

*1.3. Expected course learning outcomes*

At the end of the course, the student will be able to:
1. independently write a professional/research paper, define aims and goals of the research study,
2. independently review and use the scientific literature and other sources of knowledge,
3. understand the difference between concept and synopsis of the professional/research paper and apply it in writing,
4. apply, organise and extend the knowledge acquired during the studies on specific topic (procedural knowledge),
5. correctly use metrology of legal standard units, mathematical apparatus and mathematical terminology,
6. distinguish technical terminology from the standard language, use scientific language correctly and communicate scientifically,
7. correctly and clearly organise and show data and results in figures and tables, as well as illustrations (tables, graphs, functions, charts, diagrams, drawings, photographs, images, figures),
8. write scientific text with the proper grammar, punctuations and spelling, and properly cite references,
9. prepare and give an oral talk in the form of a seminar at a conference in the given timeframe, presenting own or other people's scientific research results,
10. take part in the critical discussions after the talks on workshops and conferences.

*1.4. Course content*

Introduction to the official rules for bachelor and diploma thesis. Collecting and studying the literature. Writing synopsis of the topic and concept of the scientific/professional paper. Articulation and writing of professional thesis and scientific paper. The structure of the professional and scientific paper. Structure of the thesis and

paper. Cohesion and unity of the text. Preparation of illustrations. Citations and bibliography. Writing and editing the final paper/thesis. Metrological correctness. Spelling, punctuations, grammar and style (clarity, simplicity and conciseness). Content of the cover and inside pages of the thesis.
Methods of presenting scientific results in a seminar and oral talk. Use of PowerPoint, Open office, Latex and other presentation tools. Oral talk in the form of a seminar in front of the scientific and professional audience. Joint analysis of the given talks, with the emphasis on the development of critical and self-critical thinking among the students. Oratory basics. Communication at professional and scientific international conferences and meetings.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☐ exercises<br>☒ long distance education<br>☒ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other |
| *1.6. Comments* | Classes are taught in the teaching space in the library with the technical assistance contractor seminars. | |

*1.7. Student's obligations*

Class attendance is mandatory. Student has to choose field and topic of his seminar/talk in the area of his bachelor thesis. He has to collect and study literature, write concept of his scientific paper and submit it for supervision, as well as to define main parts and structure of his thesis. Students are continuously supervised, especially to appropriately use metrological terminology and to follow main principles of writing a professional/scientific paper. Student has to demonstrate the outcome of his/hers work in oral presentation, and present it in front of the colleagues and supervisors. Attendance of seminars and public talks of other students in the class is mandatory. Active participation in discussions is expected.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | 0,5 | Seminar paper | 0,5 | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | | Practice | |
| Portfolio | | Elaboration and presentation of the seminar/talk | 1 | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Class attendance is mandatory and regularly supervised. Students are evaluated according to the level of their activity and motivation during the course, as well as participation in discussions. Preparation of student's seminar/talk in the form of oral talk during the class and its public oral presentation are evaluated. Preparation of the seminar/talk in order to present the results of the research study include research and review of the literature, citation of the bibliography, defining the field and main parts of the seminar/talk, writing and elaboration of the synopsis and concept of the seminar/talk, abstract writing, presentation of the research work (including figures, diagrams, etc.). Additional grade can be obtained if student participate in organising activities of the student's class conference.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. R. Zelenika: Metodologija i tehnologija izrade znanstvenog i stručnog djela, Ekonomski fakultet Sveučilišta u Rijeci, Rijeka. 2000.
2. K. Ražnjević: Jedinice Međunarodnog sustava (SI) i mjerne jedinice u Hrvatskoj, Axiom, Zagreb, 1997.

3. web sources
http://web.efzg.hr/dok/dokumenti/efzg_diplomski_seminarski_upute.pdf
http://www.vus-ck.hr/docs/Od_teme_do_diplomskog_rada.doc

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Dictionary of the Croatian language
2. Dictionary of foreign words
3. Spelling in Croatian Language

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| R. Zelenika: Metodologija i tehnologija izrade znanstvenog i stručnog djela, Ekonomski fakultet Sveučilišta u Rijeci, Rijeka, 2000. | 2 | 10 |
| K. Ražnjević: Jedinice Međunarodnog sustava (SI) i mjerne jedinice u Hrvatskoj, Axiom, Zagreb, 1997. | 3 | 10 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Questionnaire at the end of the course are designed to evaluate quality of the program, lectures and lecture materials, teaching methods and interaction with students. After the grading, student is asked to comment course program and to give suggestions about lectures and lecture materials, teaching methods and possible individual difficulties met during the process of learning.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Janka Petravić | |
| *Course title* | Mathematical Methods in Physics I | |
| *Study programme* | Undergraduate course in Physics | |
| *Course status* | Compulsory | |
| *Year* | 2nd year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 5 |
| | *Number of hours (L+E+S)* | 30+30+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The most important objectives of the course are:
- That the student obtains operational knowledge of functions of several variables, vector analysis, tensor and variational calculus as a foundation for further studies in physics;
- To introduce students to applications of the above topics in physics

### *1.2. Course enrolment requirements*

The students require the knowledge of Mathematical analysis I and II, Linear Algebra I and II. The course correlates with Mathematical Methods in Physics II and Classical Mechanics.

### *1.3. Expected course learning outcomes*

After passing the final exam, the students will be able to:
1. Solve simple and more complex problems in the calculus of several variables
2. Write and derive the fundamental identities involving the nabla operator and use them in curvilinear coordinates (spherical, cylindrical, and generalised coordinates)
3. Explain and apply the fundamental theorems in vector calculus: the divergence theorem, the Stokes theorem.
4. Solve simple problems in tensor and variational calculus and apply this knowledge to problems in physics.

### *1.4. Course content*

Partial derivatives. Taylor's theorem for functions of several variables. Extrema of functions of several variables. Conditional extrema. Multiple integration. Applications of multiple integrals in physics. Change of variables in multiple integrals. Vectors. Vector functions. Space curves. Frenet frame. Frenet-Serret formulae. Surfaces. Coordinate curves. Normal and the tangent plane of a smooth surface. Scalar and vector fields. NThe nabla operator.  Formulae and identities involving nabla. Dirac delta function. Contour integrals. Green's theorem in a plane. Conservative fields and scalar potentials. Surface integrals. Geometric definitions of grad, div and rot. Divergence theorem. Stokes' theorem. Examples for the divergence and Stokes' theorem in physics. Ternsors. Cartesian tensors. Tensor algebra. The metric tensor. Derivatives of the basis vectors and Christoffel's symbols. Variational calculus. Euler-Lagrange equation. Variational principle in physics.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☒ tutorials<br>☒ distance education | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship |

| | | |
|---|---|---|
| | ☐ fieldwork | ☐ other |

| | |
|---|---|
| *1.6. Comments* | Compulsory short seminars (5-10 minutes) and short essays will consist of extensions of the coursework. |

*1.7. Student's obligations*

- Regular attendance of lectures and tutorials and active participation in the coursework.
- Students must solve, write and submit the specified number of assignments on time.
- Pass two written exams with numerical problems during the semester.
- Pass the oral exam.

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | 0.5 | Experimental work | |
| Written exam | 1 | Oral exam | 1 | Essay | | Research | |
| Project | | Sustained knowledge check | 0.5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students' work will be assessed and marked during the course and at the final exam. Total percentage of points a student can achieve during coursework is 70, while the final exam can contibute at most 30%.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Riley K. F., Hobson M. P. Bence S. J., *Matehematical Methods for Physics and Engineering*, 3rd ed., Cambridge University Press, Cambridge, 2006.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Arfken G. B., Weber H. J., *Mathematical methods for physicists*, 6th ed., Academic Press, London, 2005.
Butkov E., *Mathematical Physics*, Addison-Wesley, Reading, 1968.
Callahan J. J., *Advanced Calculus A Geometric View*, Springer-Verlag, Heidelberg, 2010.
Chow T. L., *Mathematical Methods for Physicists: A Consise Introduction*, Cambridge University Press, Cambridge, 2000.
Demidovič B. P., i dr., *Zadaci i riješeni primjeri iz matematičke analize za tehničke fakultete*, Golden marketing, Zagreb, 2003.
Duistermaat J. J., Kolk J. A. C., *Multidimensional Real Analysis I: Differentiation*, Cambridge University Press, Cambridge, 2004.
Duistermaat J. J., Kolk J. A. C., *Multidimensional Real Analysis II: Integration*, Cambridge University Press, Cambridge, 2004.
Javor P., *Matematička analiza 2*, Element, Zagreb, 2004.
Kreyszig E., *Advanced Engineering Mathematics*, John Wiley, New York, 2006. (ili starije izdanje)
Kurepa S., *Matematička analiza, Treći dio - funkcije više varijabli*, Tehnička knjiga, Zagreb, 1989.
Lang S., *Calculus of Several Variables*, Springer USA, New York, 1987.
Mathews J., Walker R. L., *Mathematical Methods of Physics*, Addison-Wesley, Reading, 1970.
Miličić P. M., Uščumlić M. P., *Zbirka zadataka iz više matematike II*, Naučna knjiga, Beograd, 1986.
Van Brunt B., *The Calculus of Variation*, Springer-Verlag, Heidelberg, 2006.
Wong C. W., *Introduction to Mathematical Physics*, Oxford University Press, Oxford, 1991.
Zorich V. A., *Mathematical Analysis I*, Springer-Verlag, Heidelberg, 2004.
Zorich V. A., *Mathematical Analysis II*, Springer-Verlag, Heidelberg, 2004.
WWW
http://www.physics.miami.edu/~nearing/mathmethods/
http://www.maths.mq.edu.au/~wchen/ln.html
http://www.its.caltech.edu/~sean/book/unabridged.html
http://eqworld.ipmnet.ru/index.htm

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Riley K. F., Hobson M. P. Bence S. J., *Matehematical Methods for Physics and Engineering*, 3. izdanje, Cambridge University Press, Cambridge, 2006. | 1 | 15-20 |
| | | |
| | | |
| | | |
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Continuous assessment of students' participation and work ethic, assessment of homework. Students' questionnaire evaluating the quality of teaching will be conducted in the last week of the course. At the end of each semester (1 March and 30 September of the current academic year) we will analyse students' success in the exams.

| Basic description | | |
|---|---|---|
| *Course coordinator* | Assistant Professor dr.sc. Robert Peter | |
| *Course title* | MODERN PHYSICS I | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 2. year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 6 |
| | *Number of hours (L+E+S)* | 60+15+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Introduce the students to modern physics, evolving from semiclassical physics to quantum theory, with special reference to crucial experiments as well as to instruments and devices which are based on principles and laws of modern physics.

### *1.2. Course enrolment requirements*

Students must have passed the exam in Physics I and Physics II.

### *1.3. Expected course learning outcomes*

After passing the exam, student will be able to:
1. Explain the atomic structure of the matter and describe the Rutherford experiment.
2. Define the Bohr postulates and apply them to the hydrogen atom and one-electron ions.
3. Explain the difference between wave and photon description of electro-magnetic radiation and apply the photon model in the explanation of the photoelectric and Compton effect.
4. Explain the origin of line and continuous part of the X-ray spectrum.
5. Define de Broglie postulates and the uncertainty principle; describe the experiments which confirmed the wave nature of matter.
6. Apply the Schrödinger equation to the simple systems: particle in the box, tunnel effect, quantum harmonic oscillator.
7. Analyse the quantum model of hydrogen atom and apply the solution of the Schrödinger equation for H atom to many-electron atoms.
8. Explain the origin of the energy bands in the solid materials and describe the atom bonding in ionic, metal and covalent crystals.
9. Apply the free electron gas model for the description of conduction electrons in metals.
10. Explain the difference between intrinsic and extrinsic semiconductors and describe the P-N junction.

### *1.4. Course content*

Atomic structure and Periodic table of elements. Bohr theory. X-ray spectra
Atomic processes. Atoms with more than one electron. Atoms in electric and magnetic field
Wave-particle dualism for light and matter.
Wavemechanical quantum theory. Uncertainty principle. Schrödinger equation.
Condensed matter. Metals. Semiconductors. Semiconductor devices

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |

*1.7. Student's obligations*

Students are obliged to attend the course, to undergo verification of the acquired knowledge through written tests, to present a seminar paper and to pass the final course exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3,0 | Activity/Participation | | Seminar paper | 0,5 | Experimental work | |
| Written exam | | Oral exam | 1,0 | Essay | | Research | |
| Project | | Sustained knowledge check | 1,5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

The students' work is being permanently assessed and evaluated through written tests. In addition, students have to present a seminar paper during the course. The final (oral) exam carries the 40% of the total mark.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. Young H.D., Freedman R.A., UNIVERSITY PHYSICS, 9th ed., Addison-Wesley Publishing Company, Inc, 1996.
2. Krane K.S.: MODERN PHYSICS, John Wiley & Sons, Inc., New York , 1996.
3. Thorne A., Litzén U. , Johansson S., SPECTROPHYSICS, Springer-Verlag, 1999
4. Haken H., Wolf H.C., ATOMIC AND QUANTUM PHYSICS, 2nd ed., Springer-Verlag, 1984

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Halliday D., Resnick R., Walker J., FUNDAMENTALS OF PHYSICS , 6th ed., J.Wiley and Sons Inc., New York , 2003.
2. Cutnell J.D., Johnson K.W: PHYSICS, 7th ed, J.Wiley and Sons Inc., New York, 2007.
3. K. Seeger: SEMICONDUCTOR PHYSICS, Springer 1991
4. Beiser A., THEORY AND PROBLEMS OF PHYSICAL SCIENCE, Schaum's Outline Series, McGraw-Hill, 1974

http://www.physics.nmt.edu/~raymond
http://www.croeos.net/

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Young H.D., Freedman R.A., UNIVERSITY PHYSICS, 9th ed., Addison-Wesley Publishing Company, Inc, 1996. | 1 | 7 |
| Krane K.S.: MODERN PHYSICS, John Wiley & Sons, Inc., New York , 1996. | 1 | 7 |
| Thorne A., Litzén U. , Johansson S., SPECTROPHYSICS, Springer-Verlag, 1999 | 1 | 7 |
| Haken H., Wolf H.C., ATOMIC AND QUANTUM PHYSICS, 2nd ed., Springer-Verlag, 1984 | 1 | 7 |

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*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

The quality of the course will be permanently verified by the student's progress which is assessed through exams and other achievement records (solving problems during the course exercises and written tests). Additional feedback on quality and efficiency of the course is gained by implementation of a students' questionnaire at the end of the course.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Assistant Professor dr.sc. Robert Peter | |
| *Course title* | MODERN PHYSICS I | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 2. year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 5 |
| | *Number of hours (L+E+S)* | 60+15+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Introduce the students to modern physics, evolving from semiclassical physics to quantum theory, with special reference to crucial experiments as well as to instruments and devices which are based on principles and laws of modern physics.

### *1.2. Course enrolment requirements*

Students must have passed the exam in Physics I and Physics II.

### *1.3. Expected course learning outcomes*

After passing the exam, student will be able to:
1. Explain the atomic structure of the matter and describe the Rutherford experiment.
2. Define the Bohr postulates and apply them to the hydrogen atom and one-electron ions.
3. Explain the difference between wave and photon description of electro-magnetic radiation and apply the photon model in the explanation of the photoelectric and Compton effect.
4. Explain the origin of line and continuous part of the X-ray spectrum.
5. Define de Broglie postulates and the uncertainty principle; describe the experiments which confirmed the wave nature of matter.
6. Apply the Schrödinger equation to the simple systems: particle in the box, tunnel effect, quantum harmonic oscillator.
7. Analyse the quantum model of hydrogen atom and apply the solution of the Schrödinger equation for H atom to many-electron atoms.
8. Explain the origin of the energy bands in the solid materials and describe the atom bonding in ionic, metal and covalent crystals.
9. Apply the free electron gas model for the description of conduction electrons in metals.
10. Explain the difference between intrinsic and extrinsic semiconductors and describe the P-N junction.

### *1.4. Course content*

Atomic structure and Periodic table of elements. Bohr theory. X-ray spectra
Atomic processes. Atoms with more than one electron. Atoms in electric and magnetic field
Wave-particle dualism for light and matter.
Wavemechanical quantum theory. Uncertainty principle. Schrödinger equation.
Condensed matter. Metals. Semiconductors. Semiconductor devices

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| *1.6. Comments* | | |

*1.7. Student's obligations*

Students are obliged to attend the course, to undergo verification of the acquired knowledge through written tests and to pass the final course exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2,5 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 1,0 | Essay | | Research | |
| Project | | Sustained knowledge check | 1,5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

The students' work is being permanently assessed and evaluated through written tests. The final (oral) exam carries the 40% of the total mark.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. Young H.D., Freedman R.A., UNIVERSITY PHYSICS, 9th ed., Addison-Wesley Publishing Company, Inc, 1996.
2. Krane K.S.: MODERN PHYSICS, John Wiley & Sons, Inc., New York , 1996.
3. Thorne A., Litzén U. , Johansson S., SPECTROPHYSICS, Springer-Verlag, 1999
4. Haken H., Wolf H.C., ATOMIC AND QUANTUM PHYSICS, 2nd ed., Springer-Verlag, 1984

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. Halliday D., Resnick R., Walker J., FUNDAMENTALS OF PHYSICS , 6th ed., J.Wiley and Sons Inc., New York , 2003.
2. Cutnell J.D., Johnson K.W: PHYSICS, 7th ed, J.Wiley and Sons Inc., New York, 2007.
3. K. Seeger: SEMICONDUCTOR PHYSICS, Springer 1991
4. Beiser A., THEORY AND PROBLEMS OF PHYSICAL SCIENCE, Schaum's Outline Series, McGraw-Hill, 1974

http://www.physics.nmt.edu/~raymond
http://www.croeos.net/

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Young H.D., Freedman R.A., UNIVERSITY PHYSICS, 9th ed., Addison-Wesley Publishing Company, Inc, 1996. | 1 | 7 |
| Krane K.S.: MODERN PHYSICS, John Wiley & Sons, Inc., New York , 1996. | 1 | 7 |
| Thorne A., Litzén U. , Johansson S., SPECTROPHYSICS, Springer-Verlag, 1999 | 1 | 7 |
| Haken H., Wolf H.C., ATOMIC AND QUANTUM PHYSICS, 2nd ed., Springer-Verlag, 1984 | 1 | 7 |

| | | |
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| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

The quality of the course will be permanently verified by the student's progress which is assessed through exams and other achievement records (solving problems during the course exercises and written tests). Additional feedback on quality and efficiency of the course is gained by implementation of a students' questionnaire at the end of the course.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Doc. dr. sc. Darko Mekterović | |
| ***Course title*** | MATEMATICAL METHODS IN PHYSICS II | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | compulsory | |
| ***Year*** | 2. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 5 |
| | ***Number of hours (L+E+S)*** | 30+30+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The main objectives of the course are:

- for the student to acquire operational knowledge of differential equations, complex analysis and Fourier analysis
- introduce the student to the physical content and application of the topics listed.

### *1.2. Course enrolment requirements*

Cannot enroll before the course Mathematical Methods in Physics I.

### *1.3. Expected course learning outcomes*

After passing the exam the student will be able to:

1. Construct differential equations that describe simpler physical problems;
2. Solve by computer (analytically or numerically) differential equations;
3. Solve first and second order linear differential equations;
4. Calculate residue of elementary functions;
5. Solve typical examples of definite integrals by contour integration in complex plane;
6. Solve Fourier series and Fourier transform for simpler functions.

### *1.4. Course content*

Ordinary differential equations. Classification. Solution. First-order differential equations. Linear differential equations. Laplace transform. Green's functions. Series solutions of ordinary differential equations. Introduction to numerical methods. Complex functions. Cauchy-Riemann relations. Multivalued functions. Complex integrals. Cauchy integral formula. Laurent expansion. Residue theorem. Evaluation of definite integrals by contour integration in complex plane. Fourierov series and Fourier transform. Special functions.

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### *1.7. Student's obligations*

Active participation, doing home assignments and tests, passing the final exam.

### 1.8. Evaluation of student's work

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 1.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1.5 | Report | | Practice | |
| Portfolio | | | | | | | |

### 1.9. Assessment and evaluation of student's work during classes and on final exam

Students will be evaluated continuously during the course (activities marked in the table) and eventually also in the final exam. Activities during the course bring 70% and final (oral) exam 30% of the total mark.

### 1.10. Assigned reading (at the time of the submission of study programme proposal)

Boas M. L., Mathematical Methods in the Physical Sciences, 3rd edition, Wiley, 2005.

### 1.11. Optional / additional reading (at the time of proposing study programme)

Arfken G. B., Weber H. J., *Mathematical Methods for Physicists*, 6th edition, Academic Press, London, 2005.
Riley K. F., Hobson M. P. Bence S. J., *Matehematical Methods for Physics and Engineering*, Cambridge University Press, Cambridge, 2006.
Kreyszig E., *Advanced Engineering Mathematics*, John Wiley, New York, 2010.
Butkov E., *Mathematical Physics*, Addison-Wesley, Reading, 1968.
Mathews J., Walker R. L., *Mathematical Methods of Physics*, Addison-Wesley, Reading, 1970.

### 1.12. Number of assigned reading copies with regard to the number of students currently attending the course

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Boas M.L., Mathematical Methods in the Physical Sciences | 2 | 10-15 |
| | | |

### 1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences

Consultations, standard anonymous student questionnaires, discussions after the final exam..

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| **Basic description** | | |
|---|---|---|
| ***Course coordinator*** | Prof. dr. sc. Dijana Dominis Prester | |
| ***Course title*** | MODERN PHYSICS II | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Compulsory | |
| ***Year*** | 2. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 6 |
| | ***Number of hours (L+E+S)*** | 60+15+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

This course is designed to give the fundamental knowledge in some parts of modern physics. To develop analytical, logical and abstract opinions, indispensable in physical considerations, and understanding of experimental techniques of modern physics.

### *1.2. Course enrolment requirements*

Physics I and II.

### *1.3. Expected course learning outcomes*

Realization of the previously quoted objectives is expected, and the adoption of the course program in order to use the knowledge in the other parts of physics and interdisciplinary fields.

After successfully acomplished course, the student will be able to:

- Describe blackbody radiation. Differentiate continuous and line spectra. Define Wien's and Stefan's law. Derive Planck's law of blackbody radiation.
- Analyse bonding of atoms into molecules. Differentiate covalent from ionic bond.
- Differentiate electron, vibrational and rotational molecular energy transitions. Explain selection rules of molecular transitions.
- Explain Raman effect and describe examples.
- Define plasma. Describe plasma systems. Differentiate plasma frequencies. Explain Sunspots and Solar protuberances.
- Describe basic nuclear structure.
- Define radioactivity and radioactive decay.
- Differentiate models of atomic nucleus. Describe nuclear bonding and nuclear reactions.
- Differentiate elementary particles and describe their classification.
- Apply conservation laws to particle reactions and their interactions.
- Describe photoelectric and Compton effect. Analyse electron-positron pair production.
- Describe The Standard Model.

### *1.4. Course content*

Electromagnetic radiation. Blackbody radiation. Molecular structure. Molecular energy states and transitions (electronic, rotation, vibration). Molecular spectra. Raman effect. Plasma. Structure of atomic nuclei. Radioactivity. Nuclear models. Radioactive decay. Nuclear reactions. Elementary particles. Conservation laws. Fundametal forces. Classification of elementary particles. Mechanism of interaction between elementary particles. Particle intereactions. The Standard Model.

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|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☒ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | During the course students will visit laboratories active in the fields covered through this course, according to the current financial situation. | |

***1.7. Student's obligations***

Attendance at all classes and active participation is expected. Written and oral exams.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance and activity | 2,5 | Portfolio | | Seminar presentation | 0.8 | Experimental work | |
| Written exam | | Oral exam | 1,5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1,2 | Report | | Practice | |
| | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

During the classes students can obtain up to 55% of the final grade through activity and sustained knowledge check. Minimum of 27,5% is needed in order to attend the final exam. Minimum 50% in total is requested to acomplish the course.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

Krane, K. S. Modern physics, John Wiley& Sons, New York, 1995.
Eisberg, R., Resnick, R. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, John Wiley& Sons, New York, 1985.

***1.11. Optional / additional reading (at the time of proposing study programme)***

Gautreau, R. Schaum's Outline of Modern Physics, McGraw-Hill, New York, 1999. Bransden, B.H., Joachain, C. J. Physics of Atom and Molecules, Prentice Hall, 2002. Serway, R. A., Moses, C. J., Moyer, C. A. Modern Physics, Brooks Cole, 2004. Llewellyn, R., Tipler, P. A. Modern Physics, W. H. Freeman & Co., 2002.
Vršnak, B.: Temelji fizike plazme, Školska knjiga Zagreb, 1996.
Furić, M., Moderne eksperimentalne metode, tehnike i mjerenja u fizici, Školska knjiga, Zagreb, 1992.

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
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***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

Discussions with students about difficulties, origining eventually in course objectives realization.
Anonimous questionnaire designed to evaluate quality of course program, lectures and lecture materials, teaching methods and interaction with students at the end of the course.

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| Basic description | | |
|---|---|---|
| *Course coordinator* | Prof. dr. sc. Janka Petravić | |
| *Course title* | Physical Chemistry | |
| *Study programme* | Undergraduate course Physics | |
| *Course status* | Compulsory | |
| *Year* | 3rd year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 6 |
| | *Number of hours (L+E+S)* | 30+30+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Obtaining new knowledge in the field of physical chemistry
Obtaining knowledge in some advanced areas in of physical chemistry
Application of obtained knowledge to independent problem-solving
Understanding experimental and analytical methods needed for investigation of physico-chemical properties of environmental systems and processes.

### *1.2. Course enrolment requirements*

Passed exams in Physics 1 and 2, attended lectures in Mathematical Methods in Physics 1

### *1.3. Expected course learning outcomes*

After completing the final exam, students will be able to:
- Explain the structure and changes in substances at the molecular level.
- Independently solve numerical and theoretical problems in chemical thermodynamics, electrochemistry and chemical kinetics.
- Analyse chemical systems and processes in the environment in light of the laws of physical chemistry.

### *1.4. Course content*

**Chemical thermodynamics.** Basic ideas. First, second and third law of thermodynamics. State functions. Heat capacity. Chemical composition. Chemical processes. Partial molar quantities. Entropy. Perfect gas equation. Ideal mixtures. Real gases. Intermolecular interactions. Liquids. Chemical potential. Relative activity. Fugacity and its dependence on the mixture composition. Triple point. The phase rule. Real solutions. Coligative properties. Limits of the phenomenological method. **Chemical kinetics.** Definition of the reaction rate and the rate of change of concentration. Chemical equilibrium. Reaction constant. Reaction kinetics formalism. First order reactions. Second order reactions. Simultaneous reactions. Chain reactions. Dependence of the reaction rate on temperature. Collision theory. Thermodynamic properties of ions in solution. Activity of ions. **Electrochemistry.** Electrochemical cell. Electrode reactions. Types of electrodes. Types of electrochemical cells. Reactions in electrochemical cells. Nernst equation. Standard potential.

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| *1.5. Teaching methods* | ☒ lectures | ☒ individual assignments |
| | ☐ seminars and workshops | ☒ multimedia and network |
| | ☒ tutorials | ☐ laboratories |
| | ☒ long distance education | ☐ mentorship |
| | ☐ fieldwork | ☐ other |

| *1.6. Comments* | |
|---|---|

*1.7. Student's obligations*

Attendance of lectures and tutorials. Active participation in coursework. Completing homework. Taking part in two written exams. Completing and explaining practical work.

*1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 2 | Oral exam | 1.5 | Essay | | Research | |
| Project | | Sustained knowledge check | 0.5 | Report | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Attendance of lectures and especially tutorials, as well as active course participation, will be monitored regularly. Taking part in two written exams and in the final oral exam is compulsory. In order to pass, it is necessary to to obtain at least half of the available points at each step of the examination process.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

P.W. Atkins, Physical Chemistry, 5th Ed., Oxford University Press, 1994.
V. Simeon, Termodinamika, Školska knjiga, Zagreb 1980.

*1.11. Optional / additional reading (at the time of proposing study programme)*

P. W. Atkins, The Elements of Physical Chemistry, 3rd Ed., Oxford University Press, 2000.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| P.W. Atkins, Physical Chemistry, 5th Ed., Oxford University Press, 1994. | 1 | 5 |
| V. Simeon, Termodinamika, Školska knjiga, Zagreb 1980. | 1 | 5 |
| P. W. Atkins, The Elements of Physical Chemistry, 3rd Ed., Oxford University Press, 2000. | 1 | 5 |
| | | |
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| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Regular monitoring of students' participation in lectures and tutorials, with feedback about perceived progress and achievement. At the start of the course, a questionnaire about each student's expectations from the course. Final anonymous questionnaire about the quality of the course. After the final exam, the teacher will ask feedback about the goals reached in the course: the teaching method, difficulties in understanding parts of the curriculum and suggestions for improvement.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Petra Jagodnik | |
| ***Course title*** | Physical geology | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3rd | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 3 |
| | ***Number of hours (L+E+S)*** | 30+10+0 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

Students in this course should acquire basic knowledge of Earth's structure and plate tectonics, rock types (i.e., igneous, sedimentary and metamorphic rocks), as well as different types of active geomorphological processes, such as weathering of rocks and formation of soils, mass wasting, and stream processes. Students should also acquire general knowledge of geologic time and geological evolution of different types of landscapes.

### 1.2. Course enrolment requirements

Physics I

### 1.3. Expected course learning outcomes

Students in this course should:
- gain inside into the general principles of Earth's structure and inner dynamics
- be able to identify different types of igneous, sedimentary and metamorphic rocks
- understand the difference in physical properties between rock and soil materials, as well as the principles in which soil is formed
- get to know the basic principles of groundwater dynamics
- understand the role and importance of hydrogeological properties of rocks and soils for underground pollution transfer
- get to know karst forms, and understand the basic principles of karst hydrogeology
- recognize different landscapes formed by geomorphological processes, in particular landslides and other mass movements phenomena
- be able to use a basic geological map, and to understand the role of geological research in environmental protection

### 1.4. Course content

- Geology and the Earth
- Earth's structure and plate tectonics, vulcanism
- Minerals
- Igneous, sedimentary and metamorphic rocks
- Geological structures
- Weathering and formation of soil
- Physical properties of soils
- Ground water
- Streams, fluvial and erosional landscapes
- Karstification and karst landscapes
- Mass wasting
- Earthquakes
- Geologic time and geological mapping

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

***1.7. Student's obligations***

Active participation during the teaching process.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1 | Activity/Participation | 0.1 | Seminar paper | | Experimental work | |
| Written exam | 0.5 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1.4 | Report | | Practice | |
| Portfolio | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

Students work is assessed and evaluated during the classes and on final exam. Total number of credits a student can achieve during the semester is 70, while during the final examination can achieve 30 points. To pass the final exam, it is necessary to achieve a minimum of 50 %.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

Pavelić, D. (2015): Opća geologija. Rudarsko-geološko-naftni fakultet Sveučilišta Zagrebu, Zagreb. (in Croatian)
Tišljar, J. (2004): Petrologija s osnovama mineralogije. Rudarsko-geološko-naftni fakultet Sveučilišta Zagrebu, Zagreb. (in Croatian)

***1.11. Optional / additional reading (at the time of proposing study programme)***

Tišljar, J. (2001): Sedimentologija karbonata i evaporita. Institut za geološka istraživanja, Zagreb. (in Croatian)
Tišljar, J. (2004): Sedimentologija klastičnih i silicijskih taložina. Institut za geološka istraživanja, Zagreb. (in Croatian)
Press, F., Siever, R., Grotzinger, J. & Jordan, T.H. (2004): Understanding Earth 4th ed. W.H. Freeman and Company, New York.
Gonzalez de Vallejo, L.I., Ferrer, M. (2011): Geological Engineering, CRC Press, Taylor & Francis Group, London.
Benac, Č. (2013): Rječnik pojmova u primijenjenoj geologiji i geološkom inženjerstvu. Sveučilište u Rijeci (e-izdanje). (in Croatian)

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

Feedback on course quality and achievements is obtained through communication to students and consultation hours. Student's progress and adopted level of integrated thinking is being followed during the course.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Assistant Professor Ivana Poljančić Beljan, Ivana Jelovica Badovinac | |
| *Course title* | PHYSICS I: MECHANICS | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 1st year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 8 |
| | *Number of hours (L+E+S)* | 45+45+0 |

## 1. COURSE DESCRIPTION

### 1.1. *Course objectives*

Objectives of this course are to introduce fundamental knowledge of the physics required for continuing of physics programme.

### 1.2. *Course enrolment requirements*

It is presumed the knowledge of Basic mathematics. Course is in correlation with other physics courses from 1st and 2nd year of study programme (Physics II to IV) and it is basis for the performance of Physics laboratory I, II, III, IV and of all subsequent physics courses.

### 1.3. *Expected course learning outcomes*

After passing the examination students will be able to:
− compare basic and deduced magnitudes in physics as well as scalar and vector quantities,
− compare coordinate systems and distinguish linear from nonlinear motion of particles, − define Newton’s laws of mechanics,
− apply Hook’s law, derive and describe harmonic and anharmonic motions,
− describe and derive magnitudes in dynamics,
− describe and derive Newton’s law of gravity,
− compare inertial and noninertial systems,
− describe and apply consequences of Lorentz transformation equations,
− describe activity of forces in rigid body mechanics,
− define, derive, describe and apply force’s momentum, angular momentum and moments of inertia,
− describe on appearance of surface tightness and capillarity,
− distinguish statics from fluid dynamics.

### 1.4. *Course content*

Introduction. Intuition and measurements. Basic and deduced magnitudes in physics and measurement's units. Mechanics of particles. Linear and nonlinear motions. Newton's laws of mechanics. Newton's law of gravity. The gravitational field and gravitational potential. Conservation of energy, conservation of linear momentum and their applications. Inertial and noninertial systems. Consequences of special relativity and relativistic mechanics. Rigid body mechanics. Harmonic and anharmonic motions. Fluid mechanics.

| | | |
|---|---|---|
| 1.5. *Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☒ long distance education | ☐ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☒ mentorship |

| | | |
|---|---|---|
| | ☐ fieldwork | ☐ other |

1.6. *Comments*

1.7. *Student's obligations*

Student's obligations consist in attendance at lectures and exercises in accordance to regulation of study. To access final exam, student has to achieve 50% of maximal number of credits available at 2 sustained knowledge checks.

1.8. *Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 2,5 | Essay | | Research | |
| Project | | Sustained knowledge check | 2,5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students work will be evaluated and assessed during the semester and final exam. Total number of credits a student can achieve during the semester is 50, while during the final examination can achieve 50 points. The detailed working out ways of monitoring and evaluation of student's work will appear in the performing level courses.

1.10. *Assigned reading (at the time of the submission of study programme proposal)*

Udžbenik fizike Sveučilišta u Berkeleyu, 1, Tehnička knjiga, Zagreb, 1982.
Halliday, D., Resnick, R., Walker, J, Fundamentals of Physics, 6th ed, J. Wiley and Sons Inc., New York, 2003.

1.11. *Optional / additional reading (at the time of proposing study programme)*

Kulišić, P., Mehanika i toplina, Školska knjiga, Zagreb, 1987.
The Feynman Lectures on Physics, 1, California Institute of Technology, 1975.

WWW
http://www.physics.harvard.edu/problems.htm

1.12. *Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Udžbenik fizike Sveučilišta u Berkeleyu, 1, Tehnička knjiga, Zagreb, 1982. | 2 | 20 |
| Halliday, D., Resnick, R., Walker, J, Fundamentals of Physics, 6th ed, J. Wiley and Sons Inc., New York, 2003. | 3 | |

1.13. *Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Student's portfolio: Continuous assessment of student's work. Questionnaires: Questionnaire on student's expectations at the beginning of the course. Questionnaire at the end of the course designed to evaluate quality of course programme, lectures and lecture materials, teaching methods and interaction with students. After oral exam student is asked to comment course programme and to give suggestions about lecture materials, teaching methods and possible individual difficulties met during process of learning.

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| **Basic description** | | |
|---|---|---|
| ***Course coordinator*** | Mladen Petravić | |
| ***Course title*** | PHYSICS II: ELECTRICITY AND MAGNETISM | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Compulsory | |
| ***Year*** | 1. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 8 |
| | ***Number of hours (L+E+S)*** | 45+45+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Objectives of this course are to introduce fundamental knowledge of electricity and magnetism required for continuing of physics program.

### *1.2. Course enrolment requirements*

/

### *1.3. Expected course learning outcomes*

General: understanding of basic concepts and features of electricity and magnetism, development of physical way of thinking as well as skills for solving numerical and conceptual problems of electricity and magnetism.
Particular, student will be able to
1. define and distinguish basic concepts and laws of electrostaitcs and apply them on the calculus of forces and fields in electrostatics
2. define capacity, describe capacitors, apply definition of capacity on the numerical determination of capacity of the capacitors
3. define and distinguish basic concepts and laws concerning direct current and apply them to solve numerical problems
with capacity, resistance and physical parameterst of current circuits
4. define and distinguish basic concepts and laws of conductivity of gases, fluids and metals
5. define and distinguish basic concepts and laws of magnetism and geomagnetism and apply them to solve numerical problems concerning magnetic induction
6. define and distinguish basic concepts and laws concerning alternating current and apply them
7. describe magnetic properties of materials
8. describe and distinguish Maxwells equations
9. derive equation of electromagnetic wave from Maxwell equation
10. describe and analyse fundamental experiments of electricity and magnetism

### *1.4. Course content*

Electric charge. Coulomb's law. Electric field. Gauss's law. Electric potential. Electric dipole. Capacitance and capacitors. Direct current. Ohm's law. Resistance. Electric current loops.
Current in gases. Electrical conductivity of electrolytes. Electrical conduction in solids. Magnetism. Geomagnetism. Lorenz's force. Magnetic induction. Magnetic materials. Faraday's law of electromagnetic induction. Ampere's law. Maxwell's equations. Alternating current. Electromagnetic waves.

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops | ☐ individual assignment<br>☒ multimedia and network |

| | | |
|---|---|---|
| | ☒ exercises<br>☒ e- learning (long distance education)<br>☐ fieldwork | ☐ laboratories<br>☐ mentorship<br>☒ other |
| ***1.6. Comments*** | / | |

***1.7. Student's obligations***

Attendance at all classes and active participation is expected. Final written and oral exam.
The Physics I course is required to enroll this course.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | 3 | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

Students work will be evaluated and assessed during the semester and final exam. Total number of credits a student can achieve during the semester is 70 (to assess the activities listed in the table), while during the final examination can achieve 30 points.
The detailed working out ways of monitoring and evaluation of students' work will appear in the performing level courses.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

Halliday D., Resnick R., Walker J., FUNDAMENTALS OF PHYSICS, 6th ed., J.Wiley and Sons Inc., New York, 2003.
Kulišić P., Lopac V. ELEKTROMAGNETSKE POJAVE I STRUKTURA TVARI, ŠK, Zagreb, 1991.

***1.11. Optional / additional reading (at the time of proposing study programme)***

Cindro N. *FIZIKA 2*, ŠK, Zagreb, 1985.
Purcell E. M. *ELECTRICITY AND MAGNETISM*, Berkeley Physics Course, Vol 2., Mc Graw Hill, New York, 1965.
Yavorski B. and Pinsky A. *FUNDAMENTALS OF PHYSICS* Vol.1., MIR Pub., Moscow, 1975

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Halliday D., Resnick R., Walker J., FUNDAMENTALS OF PHYSICS, 6th ed., J.Wiley and Sons Inc., New York, 2003. | 1 | 15-20 |
| Kulišić P., Lopac V. ELEKTROMAGNETSKE POJAVE I STRUKTURA TVARI, ŠK, Zagreb, 1991. | 5 | 15-20 |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

*Students' portfolio:* Continuous assessment of students' work.
*Questionnaires:* Questionnaire on student's expectations at the beginning of the course.
Questionnaire at the end of the course designed to evaluate quality of course program, lectures and lecture materials, teaching methods and interaction with students.
After oral exam student is asked to comment course program and to give suggestions about lectures and lecture materials, teaching methods and possible individual difficulties met during process of learning

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| Basic description | | |
|---|---|---|
| *Course coordinator* | Professor Rajka Jurdana-Šepić | |
| *Course title* | PHYSICS III: WAVES AND OPTICS | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 2nd | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 7 |
| | *Number of hours (L+E+S)* | 45+30+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Objectives of this course are to introduce fundamental knowledge of the physics of waves and optics required for continuing of physics program.

### *1.2. Course enrolment requirements*

/

### *1.3. Expected course learning outcomes*

After passing the exam the student will be able to
1. formulate the basic concepts of wave physics (wave, frequency and period of wave, wave number, wavelength, wave equation, energy and wave velocity, superposition, interference, deflection)
2. distinguish the types of waves and apply the laws of wave motion to the calculation of physical parameters associated with wave motion
3. formulate the Doppler effect and apply the relation
4. define the basic concepts and concepts of acoustics and apply the principles of solving numerical examples
5. formulate the laws of geometric optics and apply them to the calculation of the physical parameters of optical systems (diopters, planparallel plates, optical prisms, mirrors, spherical diopters, lenses, lens systems, magnifiers, binoculars, telescope, microscope, optical instruments)
6. describe the anatomy of the eye, explain image formation by the eye, emetropies and corrections
7. define dispersion, explain the colour perception and possible anomalies
8. formulate basic experiments, concepts and phenomena with natural light wave (interference, Young's experiment, diffraction, polarization)

### *1.4. Course content*

Nature of waves. The speed of the wave. The mathematical description of the wave. Wave equation. Superposition of waves. Standing waves. Energy of wave. The nature of sound. Speed of sound. The Doppler effect. Reflection and refraction of light. Images. Mirrors. Lenses. Human Eye. Optical instruments. Light as electromagnetic wave. Dispersion. Colours. Interference. Diffraction. Resolving power. Fotometry.. Speed of light. Polarization.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☐ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☒ mentorship<br>☐ other |

| | |
|---|---|
| *1.6. Comments* | / |

*1.7. Student's obligations*

Attendance at all classes and active participation is expected. Final written and oral exam. The Physics I course is required to enroll this course.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2,5 | Activity/Participation | 0,5 | Seminar paper | | Experimental work | |
| Written exam | 2 | Oral exam | 1 | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students work will be evaluated and assessed during the semester and final exam. Total number of credits a student can achieve during the semester is 70 (to assess the activities listed in the table), while during the final examination can achieve 30 points. The detailed working out ways of monitoring and evaluation of students' work will appear in the performing level courses.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Halliday D., Resnick R., Walker J., FUNDAMENTALS OF PHYSICS, 10th ed., J.Wiley and Sons Inc., New York, 2013.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Cutnell J.D., Johnson K.W., Young D., Stadler S.; Physics, J. Wiley and Sons, 11th edition, 2018.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Halliday D., Resnick R., Walker J., FUNDAMENTALS OF PHYSICS | 1 | 20 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Students' portfolio: Continuous assessment of students' work. Questionnaires: Questionnaire at the end of the course designed to evaluate quality of course program, lectures and lecture materials, teaching methods and interaction with students. After oral exam student is asked to comment course program and to give suggestions about lectures and lecture materials, teaching methods and possible individual difficulties met during process of learning.

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | doc. dr. sc. Ivana Jelovica Badovinac | |
| *Course title* | PHYSICS IV: THERMODYNAMICS AND BASIC STATISTICAL PHYSICS | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 2nd year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 8 |
| | *Number of hours (L+E+S)* | 60+30+0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

Objectives of this course are to introduce fundamental knowledge of heat phenomena and statistical physics required to continuing of physics programme.

*1.2. Course enrolment requirements*

It is presumed the knowledge of Basic mathematics, Mathematical Analysis, Physics I, II and III. This course is basis for the performance of Physics laboratory I, II, III, IV and of all subsequent physics courses.

*1.3. Expected course learning outcomes*

After passing the examination students will be able to:

1. define basic concepts of heat phenomena,
2. apply laws of gases as well as gas state equation,
3. analyze and apply different forms of heat transfer,
4. use thermodynamic state diagrams of real substances and calculate their basic state quantities,
5. derive the basic thermodynamics relation and equation of energy and apply them to determine other useful relationships among thermodynamic parameters,
6. describe the phase transformations and derive the Clausius-Clapeyron equation,
7. compare heat capacities and derive relation among them,
8. describe the phase space and distinguish elementary presumptions of statistical mechanics,
9. derive the Maxwell's law of velocity distribution and analyze three characteristic velocities,
10. derive the Boltzmann's distribution,
11. describe the quantization of energetic spectra,
12. distinguish the Bose-Einstein and Fermi-Dirac distributions.

*1.4. Course content*

Basic concepts of heat phenomena. Gas laws. Heat transfer. Concepts of molecular-kinetics theory of matter. Laws of thermodynamics. Concept of entropy. Basic and general thermodynamics relations. Heat capacity. Thermodynamic's potentials. Phase equilibrium. Probability calculations. Elementary presumptions of statistical mechanics. Differentiation and nondifferentiation of particles. The Maxwell-Boltzmann distribution. Partition function. Quantization of energetic spectra. Bose-Einstein and Fermi-Dirac distributions.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☒ mentorship |

| | | |
|---|---|---|
| | ☐ fieldwork | ☐ other |

| | |
|---|---|
| *1.6. Comments* | The course consists from lectures, seminars and exercises adopted to attain outcomes specified before. |

*1.7. Student's obligations*

Student's obligations consist in attendance at all classes in accordance to regulation of study. Active participation is expected. Final oral exam is obliged.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 3.00 | Activity/Participation | 0.50 | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | 2.50 | Essay | | Research | |
| Project | | Sustained knowledge check | 2.00 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students work will be evaluated and assessed during the semester and final exam. Total number of credits a student can achieve during the semester is 70, while during the final examination can achieve 30 points. The detailed working out ways of monitoring and evaluation of student's work will appear in the implementation plan of the course.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Paić, M., *Toplina i termodinamika*, Školska knjiga, Zagreb, 1994.
Šips, V., *Uvod u statističku fiziku,* Školska knjiga, Zagreb, 1990.
Lenac, Z., Šips, V. Zadaci iz statističke fizike I, Liber, Zagreb, 1980.
Lenac, Z., Šips, V. Zadaci iz statističke fizike II, Liber, Zagreb, 1981.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Kulišić, P., *Mehanika i toplina*, Školska knjiga, Zagreb, 2005.
*The Feynman Lectures on Physics, 1*, California Institute of Technology, 1975.
Roy, B.N., *Fundamentals of Classical and Statistical Thermodynamics*, John Wiley & Sons, 1982.
Schroeder D.V., An introduction to thermal physics, Weber State University, Addison-Wesley, 1999.
Halliday, D., Resnick, R., Walker, J., *Fundamentals of Physics*, 6th ed, J. Wiley and Sons Inc., New York, 2003.

WWW
http://www.physics.harvard.edu/problems.htm
http://scienceworld.wolfram.com/physics/
http://physics.weber.edu/thermal/

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Paić*, Toplina i termodinamika*, Školska knjiga, Zagreb, 1994. | 5 | 30 |
| Šips, V., *Uvod u statističku fiziku*, Školska knjiga, Zagreb, 1990. | 5 | |
| Lenac, Z., Šips, V. Zadaci iz statističke fizike I, Liber, Zagreb, 1980 | 5 | |
| Lenac, Z., Šips, V. Zadaci iz statističke fizike II, Liber, Zagreb, 1981. | 5 | |
| | | |
| | | |

| *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences* |
|---|
| Student's portfolio: Continuous assessment of student's work. Questionnaires: Questionnaire on student's expectations at the beginning of the course. Questionnaire at the end of the course designed to evaluate quality of course programme, lectures and lecture materials, teaching methods and interaction with students. After oral exam student is asked to comment course programme and to give suggestions about lecture materials, teaching methods and possible individual difficulties met during the learning process. |

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| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Assistant Professor dr.sc. Iva Šarić | |
| *Course title* | PHYSICS LABORATORY I | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 1. year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 3 |
| | *Number of hours (L+E+S)* | 0 + 0 + 45 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

Introducing the student to the skills in measurement, statistical analysis of results, display and interpretation of measurement results, establishing a connection of experimental to theoretical approach to the subject, developing an conceptual understanding.

*1.2. Course enrolment requirements*

Passed the examination in Physics I (Mechanics)

*1.3. Expected course learning outcomes*

The students will at the end of this course be able to:

Developing specific skills in experimental measurement, gaining competence in statistical analysis, display and interpretation of experimental results, as well as developing ability to connect theory to experimental measurement.

1. write preparation materials for experimental measurements,
2. apply content from mechanics in exercises,
3. precisely conduct measurements in the laboratory,
4. display the measured experimental results,
5. do a statistical analysis of the acquired data and display the results
6. graphically display the results of the measurements,
7. explain the results of the measurements,
8. to connect theory to experimental measurement,
9. describe and explain the physical facts connected with the laboratory exercises,
10. argumentatively discuss the topics related to carried out laboratory exercises.

*1.4. Course content*

Introduction to measurement and correct display of experimental results. Calculation of experimental errors and statistical analysis of experimental results. Direct measurement of length. Indirect measurement of distances and radii of spherical surfaces. Measurement of weight and inertia. Density of solid bodies and liquids. Uniformly accelerated motion (Atwood's free fall device). Checking the 2$^{nd}$ Newton's law. Harmonic oscillation. Torsion. Rotational motion of objects. Measurement of rotational inertia for different objects. Measurement of gravitational acceleration by pendulum. Surface tension of liquids. Viscosity. Fluid flow. Aerodynamic buoyancy.

| | | |
|---|---|---|
| *1.5. Teaching methods* | ☐ lectures<br>☒ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☒ mentorship<br>☐ other |
| *1.6. Comments* | Students are obliged to write a lab preparation in advance. Measurements and statistical evaluation of results is done in laboratory. A completed measurement evaluation and discussion is submitted in the form of seminar paper. The corrections and assessment of work on consultation hours. | |

*1.7. Student's obligations*

Preparation for every lab work is needed, which is checked by a sustained knowledge check before every exercise. Measurement results need to be within expected experimental errors, evaluation and calculation done precisely, discussion and conclusions drawn correctly. Finished previous and prepared next lab exercise is required for access to measurement. Obligatory consultations for correction of negatively assessed papers. Students are obliged to attend laboratory classes regularly; missing the class possible twice in semester, but all the measurements should be done during the semester. All seminar papers should be approved and signed in order to access the final course exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1,5 | Activity/Participation | | Seminar paper | 0,6 | Experimental work | |
| Written exam | | Oral exam | 0,5 | Essay | | Research | |
| Project | | Sustained knowledge check | 0,4 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Student's work and progress is followed continuously: the knowledge is assessed colloquially during the laboratory measurements, written evaluations are assessed regularly. Organized and connected knowledge, as well as conceptual understanding on subject is assessed on final course exam.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

Laboratory I working materials. Marković B., Miler D., Rubčić A., Račun pogrešaka i statistika, Liber, Zagreb, 1987.

*1.11. Optional / additional reading (at the time of proposing study programme)*

Required literature for Physics I course. Wilson J. D., Physics Laboratory Experiments, 5th edition, Houghton Mifflin Company, Boston, 1998. Gymnasium textbooks in physics.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Laboratory I working materials. | 8 | 8 |
| Marković B., Miler D., Rubčić A., Račun pogrešaka i statistika, Liber, Zagreb, 1987. | 1 | 8 |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Feedback on course quality and achievements is obtained from permanent communication to students in lab and on consultation hours. Student's progress and adopted level of integrated thinking is being followed during the course.

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| **Basic description** | | |
|---|---|---|
| ***Course coordinator*** | Prof. dr. sc. Rajka Jurdana-Šepić | |
| ***Course title*** | PHYSICS LABORATORY II | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Compulsory | |
| ***Year*** | 2. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 3 |
| | ***Number of hours (L+E+S)*** | 0 + 0 + 45 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

The objectives of this course is to acquaint students with the skills of performing measurements and statistical processing of measurement results, presentation and interpretation of measurement results; connect experimental and theoretical approaches to the contents that develop physical concepts of electricity and geometric optics.

### 1.2. Course enrolment requirements

Passed the examination in Physics II (Electricity and Magnetism). The course cannot be enrolled before the courses Physics laboratory I and Physics III (Waves and optics).

### 1.3. Expected course learning outcomes

At the end of the course, students will be able to:
1. connect the circuits according to the given scheme,
2. apply physical content to specific exercises,
3. perform precise measurements,
4. tabulate the measurement results,
5. correctly statistically process the data and present the results,
6. graphically present the measurement results,
7. interpret measurement results and check physical laws,
8. connect measurement results with theoretical knowledge,
9. describe and explain the physical facts related to the given exercises,
10. interpret cause-and-effect relations on the given contents.

### 1.4. Course content

Simple electric circuits. Complex electric circuits. Internal electrical resistance of voltage sources. Ampermeter and voltmeter measurement range extension. Measurement of electrical resistance, coil inductivity and capacitor capacity. Reflection of light on plane mirror. Refraction of light on prism and half sphere. Refraction of light on lenses. Plane and spherical mirrors on optical bench. Lenses on optical bench. Microscope.

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☐ lectures<br>☒ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☒ practicum work | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratory work<br>☐ mentorship<br>☒ consultations |
| ***1.6. Comments*** | For each individual exercise, students perform measurements in a practicum and present them in a table, complete statistical processing of measured data with a discussion of the results and conclusions arrange in the form of a paper and submit as a seminar paper. | |

### 1.7. Student's obligations

Students are required to attend classes regularly and perform all prescribed exercises. For each exercise, they should prior prepare for its performance, correctly and accurately measure all the data necessary for the preparation of the exercise, accurately calculate, correctly statistically process and discuss the results and formulate conclusions. To complete the previous exercise and preparation for the next exercise are the conditions for approaching the measurements. Students are obliged to attend laboratory classes regularly; missing the class possible twice in semester, and these exercises are to be compensated in the time provided. All performed and positively graded exercises are a necessary condition to access the final course exam.

### 1.8. Evaluation of student's work

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1,5 | Activity/Participation | | Seminar paper | | Experimental work | 0,2 |
| Written exam | | Oral exam | 0,5 | Essay | | Research | |
| Project | | Sustained knowledge check | 0,3 | Report | 0,5 | Practice | |
| Portfolio | | | | | | | |

### 1.9. Assessment and evaluation of student's work during classes and on final exam

Student work on the course will be evaluated and graded during classes and at the final exam. The total number of points that a student can achieve during classes is 70 (the activities marked in the table are evaluated), while at the final exam he can achieve 30 points. The work and progress of students is monitored continuously so that during the performance of measurements, the student's readiness is checked, and the processing of exercises is regularly reviewed. The exam tests the ability to connect content and levels of conceptual understanding. A detailed elaboration of the method of monitoring and evaluating the work of students will be presented in the course syllabus.

### 1.10. Assigned reading (at the time of the submission of study programme proposal)

Laboratory II working materials.
Marković B., Miler D., Rubčić A., Račun pogrešaka i statistika, Liber, Zagreb, 1987.

### 1.11. Optional / additional reading (at the time of proposing study programme)

Required literature for Physics II course.
Wilson J. D., Physics Laboratory Experiments, 5th edition, Houghton Mifflin Company, Boston, 1998.
Gymnasium textbooks in physics.

### 1.12. Number of assigned reading copies with regard to the number of students currently attending the course

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Laboratory II working materials | Equal to the number of students enrolled | 8 |
| Marković B., Miler D., Rubčić A., Račun pogrešaka i statistika, Liber, Zagreb, 1987. | 1 | 8 |

### 1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences

Feedback on the success of the course is obtained in constant communication with students and regular consultations during the semester according to the criteria of student progress and the adoption of an integrated way of thinking and comprehensive access to content previously elaborated in the courses Physics II and Physics III..

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | *Assoc. Prof. Marin Karuza* | |
| ***Course title*** | *PHYSICS LABORATORY III* | |
| ***Study programme*** | *Undergraduate Study Programme Physics* | |
| ***Course status*** | *Compulsory* | |
| ***Year*** | *3rd* | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | *3* |
| | ***Number of hours (L+E+S)*** | *0 + 0 + 45* |

## 1. COURSE DESCRIPTION

### 1.1. *Course objectives*

Introducing the student to the skills in measurement, statistical analysis of results, display and interpretation of measurement results, establishing a connection of experimental to theoretical approach to the subject, developing an conceptual understanding.

### 1.2. *Course enrolment requirements*

The student must have sustained Physics I and Physics II exams.

### 1.3. *Expected course learning outcomes*

After sustaining the exam the students will be capable of
1. Write a short introduction to measurements
2. Apply the physics to the exercises
3. Perform the measurements
4. Prepare the data in tabular form
5. statistically analyze the data and present the results
6. graphically present the results
7. interpret the results and check the physics behind
8. interpret the results and relate them to theory
9. describe the physics and relate them to the measurements performed
10. explain the cause-consequence relations

### 1.4. *Course content*

Mechanical waves and sound waves. Colorimetric measurements (absorption of light). Diffraction of light on slit, optical grid and fiber. Polarimeter. Determination of coil magnetic field. Determination of electron mass. Photoelectric effect. Determination of specific heat capacity. Specific heat of water vaporization and ice melting. Checking the gas laws. Checking the gas laws in terms of gas kinetic theory. Measurement of air humidity.

| | | |
|---|---|---|
| 1.5. ***Teaching methods*** | ☐ lectures<br>☒ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☒other |
| 1.6. ***Comments*** | Students are obliged to write a lab preparation in advance. Measurements and statistical evaluation of results is done in laboratory. A completed measurement evaluation and discussion is submitted in the form of seminar paper. The corrections and assessment of work on consultation hours. | |

1.7. ***Student's obligations***

The student must have sustained Physics Laboratory II and Physics II exams. The presence is obligatory and all the excerises have to be done. Short seminar about every exercise has to be prepared and a final report about the measurements and elaborated results has to be given. At most two exercises can be skipped and done at a different moment.

1.8. ***Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1,5 | Activity/Participation | 0,2 | Seminar paper | 0,2 | Experimental work | 0,2 |
| Written exam | | Oral exam | 0,5 | Essay | | Research | |
| Project | | Sustained knowledge check | 0,2 | Report | 0,2 | Practice | |
| Portfolio | | | | | | | |

1.9. ***Assessment and evaluation of student's work during classes and on final exam***

The student will be assesed and evaluated during the semester and at the final exam. The maximum number of points that can be obtained during the semester is 70, while the final exam amounts to a maximum of 30 points.

The progress of the student is evaluated continuously. During final exam the level of conceptual understanding and capacity of concept linking is evaluated,

1.10. ***Assigned reading (at the time of the submission of study programme proposal)***

1) Working materials for Physics Laboratory III
*2) Marković B., Miler D., Rubčić A., Račun pogrešaka i statistika, Liber, Zagreb, 1987.*

1.11. ***Optional / additional reading (at the time of proposing study programme)***

1) Physics I i II course books
2) Wilson J. D., Physics Laboratory Experiments, 5th edition, Houghton Mifflin Company, Boston, 1998.
3) Relevent highschool books

1.12. ***Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Working materials for Physics Laboratory III | equal to number of students | 18 |
| Marković B., Miler D., Rubčić A., Račun pogrešaka i statistika, Liber, Zagreb, 1987. | 1 | 18 |
| | | |
| | | |
| | | |
| | | |
| | | |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Doc. dr. sc. Ivna Kavre Piltaver | |
| ***Course title*** | Physics Laboratory IV | |
| ***Study programme*** | Undergraduate Study Programme PHYSICS | |
| ***Course status*** | Compulsory | |
| ***Year*** | 3 | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 6 |
| | ***Number of hours (L+E+S)*** | 0 + 0 + 60 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

1. Enable a better understanding of the theory
2. Develop creativity through active learning
3. Bring closer the phenomena on the microscale inaccessible to the visual perception
4. Consolidate elementary knowledge of physics
5. Help in the construction of physical models with as simple as possible mathematical formalism
6. Introduction to the scientific methodology of science based on the active connection between theory and experiment

### *1.2. Course enrolment requirements*

Passed exams of the courses: Physics1, 2, 3 and 4.

### *1.3. Expected course learning outcomes*

With respect to each exercise specified in the course content, the expected outcomes are:
1. Develop the ability to independently solve a new problem based on previously acquired knowledge of a specific content.
2. Design and perform an experiment with the aim to solve the given problem.
3. Critically analyze and determine the reliability of the method and the measurement results.
4. Explain the motion of electrons through electron tubes (diode, triode).
5. Describe the current flow in the forward biased and reverse biased semiconductor diode.
6. Schematically represent the basic circuits for the half-wave and full-wave AC rectifiers.
7. Explain the operation mode and the frequency characteristics of passive high- and low-pass filters.
8. Apply semiconductor diode properties in AC cut-off circuits.
9. Describe the operation mode of the derivator and integrator on the example of a rectangular input signal.
10. Explain the Franck-Hertz experiment.
11. Describe the magnetic field of the flat conductor and of the coil.
12. Explain how a simple spectrophotometer works and apply it during the measurement of the emission spectra of glowing gases and a light bulb.

### *1.4. Course content*

Students individually and independently perform the exercises according to the following contents

- Electronic tubes (diode, triode, glow lamp)
- Semiconductor element (diode)
- Rectifiers (half-wave, full-wave)
- Electronic filters (high-frequency RC filter; low-frequency RC filter, narrowband and wideband RC filter)
- Signal molding (limiting circuits; derivation and integration)
- Franck-Hertz experiment

- Magnetic field of a flat conductor and of a coil
- Spectroscopy

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☒ laboratories<br>☒ mentorship<br>☐ other |
| ***1.6. Comments*** | Regular monitoring of student activities and attitudes toward work through oral examinations, student's reports and discussion of the results. Positivly rated oral examination of each laboratory exercise is a necessary condition for its performance. Students receive feedbacks on each exercise performed and the mistakes/imperfections they are required to correct. | |

***1.7. Student's obligations***

The student can execute the practical part of the laboratory exercise once he/she positively answers the theoretical part regarding the exercise and if he/she has prepared the appropriate written preparation. After the measurements, the student has to analyse them by preparing a written report which contains the graphical representation of the results and the appropriate comments. It is mandatory to take the final exam.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 0,5 | Oral exam | 0,5 | Essay | | Research | |
| Project | | Sustained knowledge check | 1 | Report | 2 | Practice | |
| Portfolio | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

The work and progress of students is monitored on a continuous basis. Before each performance of measurements, the student has to take a brief oral exam regarding the theoretical part of the exercise he/she is performing. Sudents written preparations and reports are reviewed regularly. The aim of the final exam is to check both the student's content connection and the level of conceptual understanding.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

1. T. Jurkić, D. Kotnik-Karuza, M. Sarta-Deković,L. Mandić, N. Erceg, I. Kavre Piltaver V. Labinac, Lj. Špirić: Physical laboratory 4 (Internal teaching material of the Department of Physics).
2. D. Kotnik-Karuza: Fundamentals of Electronics with Lab Exercises, Faculty of Phylosofy Rijeka, 2000.
3. Instructions for the execution of exercises on the course page
4. Halliday D., Resnick R., Walker J., FUNDAMENTALS OF PHYSICS , 6th ed., J.Wiley and Sons Inc., New York, 2003.

***1.11. Optional / additional reading (at the time of proposing study programme)***

Millman-Halkias: Integrated electronics, Analog and digital circuits and systems, Mc Graw-Hill Kogakusha, 1972.
Nuffield Advanced Science PHYSICS: Teacher's Guide 1,2, Longman Group Ltd, Hong Kong 1988.
Nuffield Advanced Science PHYSICS: Student's Guide 1,2, Longman Group Ltd, Hong Kong 1988.
University Laboratory Experiments PHYSICS 1-5, PHYWE AG, Göttingen, 1995.
http://www.ba.infn.it/www/didattica.html

***1.12. Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| T. Jurkić, D. Kotnik-Karuza, M. Sarta-Deković,L. Mandić, N. Erceg, I. Kavre Piltaver V. Labinac, Lj. Špirić: Physical laboratory 4 (Internal teaching material of the Department of Physics). | As needed, depending on the number of students | 22 |
| D. Kotnik-Karuza: Fundamentals of Electronics with Lab Exercises, Faculty of | 10 | 22 |

| | | |
|---|---|---|
| Phylosofy Rijeka, 2000. | | |
| Halliday D., Resnick R., Walker J., *FUNDAMENTALS OF PHYSICS* , 6th ed., J.Wiley and Sons Inc., New York, 2003. | 2 | 22 |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

The complex exercises within this laboratory course include consultative work with the student, which means that he/she not only performs it independently, but in a continuous interaction with the professor develops creativity through active learning. The quality achieved in this process is a measure of the success of the course. Feedbacks on the quality and success of the course is obtained by conducting a student questionnaire at the end of the semester.

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| **Basic description** | | | |
|---|---|---|---|
| *Course coordinator* | Doc. dr. sc. Ivana Poljančić Beljan | | |
| *Course title* | PHYSICS SEMINARS | | |
| *Study programme* | Undergraduate study programme PHYSICS | | |
| *Course status* | Elective | | |
| *Year* | 3. year | | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 3 | |
| | *Number of hours (L+E+S)* | 0 + 0 + 30 | |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The main objectives of the course Physics Seminars are to extend comprehension of the concepts of general physics, and to introduce students with the content of physics beyond the standard university curricula.

### *1.2. Course enrolment requirements*

It is assumed that student has basic knowledge of general physics, but there are no courses that are prerequisites for entry.

### *1.3. Expected course learning outcomes*

After passing the exam, student will be able:
1. to translate and analyze papers in English containing topics from elementary physics;
2. to parse important and less important and compose a short seminar and presentation;
3. to prepare a poster in one of the software packages (Microsoft Office PowerPoint or CorelDraw);
3. to present a seminar before the audience and argument the answers to the questions from the audience;
4. to actively discuss about the presentation topics of their colleagues.

### *1.4. Course content*

Topics for the seminars will be selected from leading educational journals in physics: American Journal of Physics, The Physics Teacher, Physics Today, Science in Computing and Engineering, European Journal of Physics, Physics Education.

| *1.5. Teaching methods* | | |
|---|---|---|
| | ☐ lectures | ☒ individual assignment |
| | ☒ seminars and workshops | ☒ multimedia and network |
| | ☐ exercises | ☐ laboratories |
| | ☒ long distance education | ☐ mentorship |
| | ☐ fieldwork | ☐ other |

| *1.6. Comments* | |
|---|---|

### *1.7. Student's obligations*

- Students are required to write and submit two seminars: first, elaborating paper from The Physics Teacher or Physics Education, and second, elaborating paper from American Journal of Physics with more advanced topic. The seminar must be written according to the rules that will be given and explained at the beginning of the course.
- Students are required to present her/his seminar with PowerPoint presentation (Microsoft Office or OpenOffice). The duration of the presentation is limited to 10 - 20 minutes.
- Students are required to prepare a poster containing physics from one of the seminars.

- Students are to be present at the presentations of their colleagues, and are required to actively participate in discussions following the presentations.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 0.8 | Activity/Participation | | Seminar paper | 1.0 | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | | Report | 0.2 | Practice | |
| Portfolio | | Poster | 1.0 | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

There is no final exam. Students will be evaluated and assessed during the semester. Detailed elaboration of ways of monitoring and evaluation of students' work will be displayed in the Working Plan.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

JOURNALS:
American Journal of Physics (http://scitation.aip.org/ajp);
Computing in Scinece and Engineering (https://aip.scitation.org/journal/csx);
European Journal of Physics (https://iopscience.iop.org/journal/0143-0807)
Physics Education (http://www.iop.org/EJ/journal/0031-9120)
Physics Today (http://www.physicstoday.org/);
The Physics Teacher (http://scitation.aip.org/tpt).

*1.11. Optional / additional reading (at the time of proposing study programme)*

Feynman R. P., Leighton R. B., Sands M., *The Feynman Lectures on Physics*, vol. 1-3, Addison-Weseley, Reading, 1963.
*Berkeley Physics Course*, vol. 1-5, McGraw-Hill
Walker J, *Fundamentals of Physics*, 8th ed., Wiley, New York, 2008.
Young H. D., Freedman R. A., *University Physics with Modern Physics*, 11th ed., Pearson, San Francisco, 2004.

WWW
http://academicearth.org/
https://edutorij.e-skole.hr/share/page/home-page
http://ocw.mit.edu/OcwWeb/web/home/home/index.htm

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| American Journal of Physics | subscription | 10-15 |
| The Physics Teacher | subscription | |
| Physics Today | subscription | |
| Computing in Scinece and Engineering | subscription | |
| European Journal of Physics | - | |
| Physics Education | - | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Regular monitoring of the student's activity and attitude towards work. In the last week of classes, anonymous surveys will be conducted in which students will evaluate the quality of teaching.

| **Basic description** | | |
|---|---|---|
| *Course coordinator* | Associate professor, Zoran Kaliman | |
| *Course title* | Quantum Mechanics | |
| *Study programme* | Undergraduate study programme PHYSICS | |
| *Course status* | Compulsory | |
| *Year* | 3rd year | |
| *ECTS credits and teaching* | *ECTS student's workload coefficient* | 12 |
| | *Number of hours (L+E+S)* | 45+45+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Basic knowledge of fundaments of quantum physics and understanding of new concepts and principles embedded in quantum physics. Developing the cognizance how simple fundamental equations can explain complex physical phenomenon and lead to concrete applications. Developing the cognizance of the complex connection between the experiment and the theory and the specific way of explanation of the processes that cannot be directly measured.

### *1.2. Course enrolment requirements*

Prerequisites for this course are following: Mathematical methods of physics I. II, Classical mechanics I, Physics I.

### *1.3. Expected course learning outcomes*

**ORIGINS OF QUANTUM MECHANICS**

1. To describe origins of quantum mechanics.

**QUANTUM MECHANICS POSTULATES**

2. To define and explain quantum mechanics postulates.

**MATHEMATICAL TOOLS OF QUANTUM MECHANICS**

3. To use Dirac bra – ket notation.
4. To make correspondence between bra – ket and matrix notation.
5. To apply continuum bases; to define representations and connections between representations.

**SCHRÖDINGER EQUATION**

6. To derive Schrödinger equation. To derive time independent Shrödinger equation. To explain solutions of Schrödinger equation.
7. To define and solve 1D problems.
8. To separate variables in 3D spherical coordinates.

***IDENTICAL PARTICLES***

9. To explain bosons and fermions. To explain periodic table.
10. To solve helium atom.

***APROXIMATION METHODS FOR STATIONARY STATES***

11. To derive time – independent perturbation theory.
12. To derive and apply variational method

***SCATTERING THEORY***

13. To derive cross section formula.

*1.4. Course content*

**Origins of quantum mechanics:** particles and waves. Indeterministic nature of the microscopic world. **Postulates of quantum mechanics**: postulates, state of the system, observables and operators, measurements in quantum mechanics.
**Mathematical tools of quantum mechanics:** Hilbert space and wave functions. Dirac notation. Representation in discrete and continuous basis. Connection of position and momentum representation.
**Schrödinger equation**: Schödinger equation and time – independent Schrödinger equation. Properties of 1D motion. 1D problems: potential step, potential barrier, tunneling, square well, free particle, harmonic oscillator. 3D problems in spherical coordinates: central potential, hydrogen atom, angular momentum.
**Identical particles:** many particle systems, systems of identical particles, Paulli exclusion principle and periodic table, helium atom.
**Approximation methods:** Time – independent perturbation theory, variational method
**Scattering theory:** scattering and cross section. Born approximation, partial wave analysis.

*1.5. Teaching methods*

| | |
|---|---|
| ☒ lectures | ☒ individual assignment |
| ☒ seminars and workshops | ☒ multimedia and network |
| ☒ exercises | ☐ laboratories |
| ☐ long distance education | ☒ mentorship |
| ☐ fieldwork | ☐ other |

*1.6. Comments*

*1.7. Student's obligations*

- Attendance at all classes and active participation is expected.
- Students should solve, write home works.
- Students should pass two preliminary exams (or written exam) in form of numerical exercises.
- Final oral exam.

*1.8. Evaluation of student's work (ECTS credits)*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 0 | Activity/Participation | 1 | Seminar paper | 1 | Experimental work | |
| Written exam | | Oral exam | 5 | Essay | | Research | |
| Project | | Sustained knowledge check | 5 | Report | | Practice | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of student's work during classes and on final exam*

Students will be evaluated during lectures and on final exam. Maximum percentage during lectures is 60%, and on final exam 40%. On final exam student should have at least 50% point to pass.
Detailed elaboration will be given in executive program.

*1.10. Assigned reading (at the time of the submission of study programme proposal)*

1. N. Zettilli, *Quantum mechanics*, 2nd ed., Wiley, Jacksonville, 2009.
2. F. Schwabl, *Quantum mechanics*, 4th ed., Springer, Berlin, 2007.
3. Supek, *Teorijska fizika i struktura materije,* 1. i 2. dio, Školska knjiga, Zagreb, 1977.
4. J. Pade, *Quantum mechanisc for pedestrians 1*, Springer, Switzerland, 2014.
5. D. J. Griffiths, *Introduction to Quantum Mechanics,* 2nd ed., Prentice-Hall, New Jersey, 2005.
6. W. A. Harrison, *Applied quantum mechanics*, World Scientific, Singapore, 2001.

*1.11. Optional / additional reading (at the time of proposing study programme)*

1. T. T. Taylor, *Mechanics: classical and quantum,* 1st ed., California, 1976.
2. W. Greiner, *Quantum mechanics an introduction*, 4th., Springer, Berlin, 1994.
3. L. I. Schiff, *Quantum Mechanics*, 3. izdanje, McGraw-Hill, New York, 1968.
4. J. J. Sakurai, *Modern Quantum Mechanics*, 2. izdanje, Addison-Wesley, Reading, 1994.
5. F. J. Levi, *Applied Quantum Mechanics*, 2. izdanje, Cambridge University Press, Cambridge, 2006.
6. A. Messiah, *Quantum Mechanics*, North-Holland, Amsterdam, 1970.

*1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| N. Zettilli, *Quantum mechanics*, 2nd ed., Wiley, Jacksonville, 2009. | 3 | 20-25 |
| Supek, *Teorijska fizika i struktura materije*, 1. i 2. dio, Školska knjiga, Zagreb, 1977 | 10 | 20-25 |
| D. J. Griffiths, *Introduction to Quantum Mechanics*, 2nd ed., Prentice-Hall, New Jersey, 2005. | 2 | 20-25 |
| W. A. Harrison, *Applied quantum mechanics*, World Scientific, Singapore, 2001. | 1 | 20-25 |
| | | |
| | | |

*1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Discussions with the students, questionnaires, achievements on the exams. Regular monitoring students' activities.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Assistant Professor dr.sc. Tomislav Terzić | |
| ***Course title*** | Symbolic programming | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 2. year, 3. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 3 |
| | ***Number of hours (L+E+S)*** | 15+15+0 |

## 1. COURSE DESCRIPTION

### 1.1. *Course objectives*

The main objectives of the course are to introduce students to the basics of the software package for symbolic programming (different Python libraries etc.) and to instruct them how to apply symbolic programming in solving problems related to calculus and linear algebra. In this way, students gain basic knowledge about using software packages for symbolic programming for analytical and numerical calculations in physics.

### 1.2. *Course enrolment requirements*

The course assumes basic knowledge of high school computer science and the use of Microsoft Windows OS or some of Linux distributions (Debian, Ubuntu). It is recommended that students pass exams of the first year courses Mathematical Analysis I, II and Linear Algebra I, II before attending this course.

### 1.3. *Expected course learning outcomes*

After passing the exam, student will be able:

1. to use a software for symbolic programming for simple symbolic and numerical calculations;
2. to plot graphs of functions in 2-D and 3-D inculidng plot options (for example, draw graphs in color ,...);
3. to calculate derivatives and indefinite integrals of more complicated functions symbolically;
4. to calculate numerically the definite integral of continuous function;
5. to carry out various mathematical operations with matrices (a product of matrices, the calculation of eigenvalues,...);
6. to solve the system of linear and nonlinear equations symbolically or numerically, if neccesary;
7. to use lists and tables in simple examples.

### 1.4. *Course content*

*Basic operations with numbers, mathematical expressions and functions*: computing with numbers and embedded functions, graphing, solving equations. *Introduction to lists and tables*: lists and operations on lists. *Matrices and vectors*: an introduction to computing with matrices and vectors, systems of linear equations, eigenvalues and eigenvectors. *Calculus*: limits and continuity, differentiation, integration, series. *Differential equations*: first and second order differential equations, systems of differential equations.

| | | |
|---|---|---|
| 1.5. ***Teaching methods*** | ☒ lectures<br>☒ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☒ practicum |
| 1.6. ***Comments*** | | |

1.7. ***Student's obligations***

Students are obligated:

- to attend regularly and to participate actively in lectures and exercises;
- to do their homework independently;
- to pass preliminary exam and final oral exam.

1.8. ***Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.0 | Activity/Participation | 0.2 | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1.4 | Report | | Practice | 0.4 |
| Portfolio | | | | | | | |

1.9. ***Assessment and evaluation of student's work during classes and on final exam***

Student will be evaluated and assessed during the course and final exam. Maximum total percentage which student can achieve during the lessons is 70%, while the final exam (oral and written) provides 30% at best. Detailed elaboration of ways of monitoring and evaluation of students' work will be displayed in the Working Plan!

1.10. ***Assigned reading (at the time of the submission of study programme proposal)***

Abell M. L., Braselton J. P., *Matematica by Example*, 4th. ed., Elsevier Academic Press, Burlington, 2009.

1.11. ***Optional / additional reading (at the time of proposing study programme)***

Ayars E., Wilde M., Nakroshis P. A., *Computational Physics with Python*, California State University, Chico, 2013.
Pine D., *Introduction to Python for Science*, 2013.
Bauman G., *Mathematica for Theoretical Physics – Classical Mechanics and Nonlinear Dyanmics*, 2nd ed., Springer, Berlin, 2005.
Bauman G., *Mathematica for Theoretical Physics – Electrodynamics, Quantum Mechanics, General Relativity, and Fractals*, 2nd ed., Springer, Berlin, 2005.
Don E., *Schaum's Outline of Mathematica*, 2nd ed., Mcgraw-Hill, New York, 2009.
Dubin D., *Numerical and analytical methods for scientists and engineers using mathematica*, Wiley, New York, 2003.
Hoste J. *Mathematica Demystified*, Mcgraw-Hill, New York, 2009.
Ruskeepää H., *Mathematica Navigator*, 3rd ed., Elsevier Academic Press, Burlington, 2009.
Tam P. T., *A Physicist's Guide to Mathematica*, 2nd ed., Elsevier Academic Press, Burlington, 2008.
WWW
http://functions.wolfram.com/
http://demonstrations.wolfram.com/
http://mathworld.wolfram.com/
http://integrals.wolfram.com/index.jsp

1.12. ***Number of assigned reading copies with regard to the number of students currently attending the course***

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Abell M. L., Braselton J. P., *Matematica by Example*, 4th. ed., Elsevier Academic Press, Burlington, 2009. | 1 | 10 |

1.13. ***Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

Regular monitoring of the student's activity and attitude towards work. In the last week of classes, anonymous surveys will be conducted in which students will evaluate the quality of teaching.

**List of compulsory and elective courses and/or modules with teaching hours required and ECTS credits allocated**

**- Mathematics**

| LIST OF MODULES/COURSES | | | | | | | |
|---|---|---|---|---|---|---|---|
| Semester: 1 | | | | | | | |
| MODULE | COURSE | COURSE ORGANISER | L | E | S | ECTS | STATUS[1] |
| All | Calculus I | | 45 | 45 | 0 | 8 | C |
| | Linear algebra I | | 45 | 45 | 0 | 8 | C |
| Semester: 2 | | | | | | | |
| MODULE | COURSE | COURSE ORGANISER | L | E | S | ECTS | STATUS |
| All | Calculus II | | 45 | 45 | 0 | 8 | C |
| | Linear algebra II | | 45 | 45 | 0 | 8 | C |

| Semester: 3 | | | | | | | |
|---|---|---|---|---|---|---|---|
| MODULE | COURSE | COURSE ORGANISER | L | E | S | ECTS | STATUS |
| Math. | Calculus III | | 45 | 45 | 0 | 7 | E |
| Semester: 4 | | | | | | | |
| MODULE | COURSE | COURSE ORGANISER | L | E | S | ECTS | STATUS |
| Math. | Differential equations | | 30 | 30 | 0 | 6 | E |

| Semester: 5 | | | | | | | |
|---|---|---|---|---|---|---|---|
| MODULE | COURSE | COURSE ORGANISER | L | E | S | ECTS | STATUS |
| Math. | Combinatorics | | 30 | 30 | 0 | 5 | E |
| | Euclidean spaces | | 30 | 30 | 0 | 5 | E |
| | Matematical logic | | 30 | 30 | 0 | 5 | E |
| Semester: 6 | | | | | | | |
| MODULE | COURSE | COURSE ORGANISER | L | E | S | ECTS | STATUS |
| Math. | Complex analysis | | 45 | 30 | 0 | 7 | E |

1 **IMPORTANT:** Enter **C** if the course is compulsory or **E** if the course is elective.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Calculus I | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Compulsory | |
| Year | 1. | |
| Credit values and modes of instruction | ECTS credits / student workload | 8 |
| | Hours (L+E+S) | 45 + 45 + 0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

Main course objective is to get students acquainted with basic ideas, results and methods of real mathematical analysis (in one variable). For this purpose, the following units are presented to students:

- fields of real and complex numbers
- sequences of real numbers and convergence criteria
- real functions of a real variable: function limit, continuity and other properties
- differential calculus and important theorems
- application of differential calculus in the examination of properties of functions defined explicitly, implicitly and parametrically

*1.2. Course prerequisite*

None.

*1.3. Expected outcomes for the course*

After completing this course students should be able to:

- axiomatically and inductively build fields of real and complex numbers (A6, B6, D5, E5, F5)
- analyse convergence of sequences and apply convergence criteria (A6, B6, D6, E5, F5)
- apply properties of real elementary functions (A6, B6, D6, E5, F5)
- investigate the limit of a function, continuity and uniform continuity and other properties of real functions of real variable (A6, B6, D6, E5, F5)
- apply techniques of calculating the limit of a sequence of real numbers, limit and derivation of a real function of one variable (A6, B6, D6, E5, F5)
- distinguish and give examples of convergent and divergent sequences of real numbers, continuous and non-continuous functions, differentiable and non-differentiable real functions of one variable (A6, B6, D6, E5, F5)
- apply differential calculus in geometry and in examination of properties of functions defined explicitly, implicitly and parametrically (A6, B6, D6, E5, F5)
- mathematically prove validity of all procedures and formulas which are used within the course (A6, B6, D6, E6, F6).

*1.4. Course content*

Real numbers. Axioms of real numbers. Supremum and infimum. Field of complex numbers. Trigonometric form of a complex number. Binomial theorem. Function, bijection, inverse function and composition of functions. Sequence and limit. Limit of function in a point. Continuity of function in a point and on closed interval. Derivative, basic rules and differentiation of elementary functions. Application of differential calculus. The mean value theorem and applications. Monotonicity and local extrema. Convexity and inflection points. Asymptotes.

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| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[2]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 2.5 | Seminar paper | | Experiment | |
| Written exam | 2.5 | Oral exam | 2 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and in the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. S. Kurepa: Matematička analiza I, II, Tehnička knjiga, Zagreb (more editions)
2. B. P. Demidovič: Zadaci i riješeni primjeri iz više matematike, Tehnička knjiga, Zagreb (more editions)

*1.11. Recommended literature (when proposing the program)*

1. S. Lang: A First Course in Calculus, 5th ed. Springer 1986.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[2] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Linear algebra I | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Compulsory | |
| Year | 1. | |
| Credit values and modes of instruction | ECTS credits / student workload | 8 |
| | Hours (L+E+S) | 45+45+0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

The main course objective is to get students acquainted with the basic concepts of Linear algebra. For this purpose it is necessary within the course to:

- define and distinguish basic algebraic structures (groups, fields);
- define dot and cross product;
- define vector spaces, analyze their properties, and enable students to independently find bases for vector spaces;
- define matrices and enable students to independently use the basic operations with matrices;
- define the determinant of the matrix and analyze the properties of the determinant
- define the rank of matrices;
- describe different ways of determining the inverse of the matrices;
- define linear operators and algebra operators, and analyze properties of linear maps;
- define similar matrices.

*1.2. Course prerequisite*

None.

*1.3. Expected outcomes for the course*

After completing this course, the students are expected to be able to:

- apply with understanding the basic properties of algebraic structures: groups, division rings, fields and vector spaces in solving problems (A5, B5, C3, D3, E3, F2)
- demonstrate the properties of algebraic structure mapping (A4, B4, C3, D3, E2, F2)
- classify the properties of linear maps (monomorphism, epimorphism, isomorphism) (A6, B6, C6, D6, E4, F4)
- apply with understanding vector operations to solve problems (A6, B6, C6, D6, E4, F5)
- geometrically interpret the solvability of systems of linear equations in the plane and space (A6, B6, C6, D6, E4, F5)
- solve problems by applying the properties of computational operations with the matrices, the properties of determinants, rank and inverses of matrices (A6, B6, C6, D6, E6, F6)
- use matrix operations to determine the matrix of linear maps in different bases of vector spaces (A6, B6, C6, D5, E4, F5)
- mathematically prove validity of all procedures and formulas that are used within the course (A6, B6, C6,D6, E5, F5).

*1.4. Course content*

Groups, homomorphisms of groups, fields, vectors, vector spaces, matrices, basic operations with matrices, determinants, inverse matrix, rank of matrix, linear maps, vector space base transformation, similar matrices

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| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other<br>Consultations, project strategies |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[3]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 2 | Seminar paper | | Experiment | |
| Written exam | 3 | Oral exam | 2 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. S.Kurepa: Uvod u linearnu algebru, Školska knjiga, Zagreb, 1975.
2. K. Horvatić: Linearna algebra I, II I III, Sveučilište u Zagrebu, PMF, Matematički odjel, Zagreb, 1995.

*1.11. Recommended literature (when proposing the program)*

1. A. Aglić Aljinović, N. Elezović: Linearna algebra : zbirka zadataka, Zagreb : Element, 2003.
2. D. Bakić: Linearna algebra, Školska knjiga, Zagreb, 2008.
3. L. Čaklović: Zbirka zadataka iz linearne algebre, Školska knjiga, Zagreb, 1976.
4. J. Dieudonne: Linearna algebra i elementarna geometrija, Školska knjiga, Zagreb, 1977.
5. S.Kurepa: Konačnodimenzionalni vektorski prostori, Liber, Zagreb, 1992.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[3] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Calculus II | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Compulsory | |
| Year | 1. | |
| Credit values and modes of instruction | ECTS credits / student workload | 8 |
| | Hours (L+E+S) | 45+45+0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

The objective of this course is to get students acquainted with basic terms, results and methods of real mathematical analysis (in one dimension) and enable them to become independent in applying them. For this purpose, students are introduced with the following units:

- indefinite integral and methods of integration,
- definite integral and its application,
- real number series and convergence criteria,
- function sequence and series, convergence and uniform convergence,
- power series and Fourier series.

*1.2. Course prerequisite*

None.

*1.3. Expected outcomes for the course*

After completing the course, the students are expected to:

- determine indefinite and calculate definite integral (A6, B6, D6, E5, F5),
- apply with understanding integral calculus in geometry (A6, B6, D6, E5, F5),
- analyse convergence of real number series and apply convergence criteria (A6, B6, D6, E5, F5),
- differentiate and provide examples of integrable and non-integrable real function of one variable, convergent and divergent series of real numbers (A6, B6, D6, E5, F5),
- analyse convergence of function series and sequences (A6, B6, D6, E5, F5),
- develop functions into Taylor series (A6, B6, D6, E5, F5),
- analyse Fourier series (A6, B6, D6, E5, F5),
- mathematically verify methods and formulas used within this course (A6, B6, D6, E6, F6).

*1.4. Course content*

Indefinite integral. Methods of integration. Definite integral. Newton-Leibniz formula. Integrability of monotonic and continuous functions. Application of integral calculus. Improper integral. Real number series and convergence criteria. Function series and sequences. Convergence and uniform convergence of function series and sequences. Taylor's theorem. Power series and Taylor's series of elementary functions. Fourier series.

| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other |

| *1.6. Comments* | |
|---|---|

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[4]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 2.5 | Seminar paper | | Experiment | |
| Written exam | 2.5 | Oral exam | 2 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. S. Kurepa: Matematička analiza 1, 2, Tehnička knjiga , Zagreb
2. B. P. Demidovič: Zadaci i riješeni primjeri iz više matematike, Tehnička knjiga, Zagreb

*1.11. Recommended literature (when proposing the program)*

1. S. Lang: A first Course in Calculus 5th ed. Springer 1986.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[4] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Linear algebra II | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Compulsory | |
| Year | 1. | |
| Credit values and modes of instruction | ECTS credits / student workload | 8 |
| | Hours (L+E+S) | 45+45+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

This course aims to give students the basic knowledge about linear algebra, ie:

- analyse the solvability of systems of linear equations and the structure of the solution set;
- define a linear manifold;
- identify and apply different ways of solving systems of linear equations;
- define the characteristic and minimal polynomial and analyze their properties;
- define the eigenvalues of the linear operator, analyze their properties and describe methods for determining the
- eigenvalues;
- apply and understand the diagonalisation criteria of a linear operator;
- define the Jordan form of a matrix
- define a unitary spaces and norm; analyze Cauchy-Schwartz inequality;
- define the orthonormal base and orthogonal complement; describe Gram–Schmidt orthogonalisation process;
- the introduction of the concepts of linear mappings on unitary spaces;
- define the main features of the unitary, orthogonal, hermitian, symmetric and antihermitian matrices;
- analyse quadratic forms.

### *1.2. Course prerequisite*

None.

### *1.3. Expected outcomes for the course*

After completing this course students should be able to:

- solve problems by applying different methods of solving system linear equations (A6, B6, C6, D3, E3, F3);
- classify the properties of a linear maps (unitary operators, orthogonal operators, symmetric and antisymmetric operators, hermitian and antihermitian operators) (A6, B6, C6, D3, E4, F3)
- apply and understand operations with vector in problem solving (A6, B6, C6, D5, E4, F5)
- determine the Jordan form of the matrix (A4, B4, C3, D2, E2, F2)
- construct the orthonormal base of unitary space (A6, B6, C6, D4, E3, F5)
- use vector and matrix norms to solve problems (A6, B6, C3, D2, E2, F2)
- distinguish unitary, normed and metric spaces (A6, B6, C3, D2, E2, F2)
- determine the canonical form of (binary) quadratic form (A4, B4, C3, D2, E2, F2)
- mathematically prove validity of all procedures and formulas that are used within the course (A6, B6, C6, D6, E5, F5)

### *1.4. Course content*

Systems of linear equations. The Cramer's rule. Homogeneous and non-homogeneous systems. Solving s Systems of linear equations. Characteristic and minimal polynomial. The invariant subspaces. Eigenvalues of linear operator. Jordan form of a matrix. Unitary spaces, Schwartz-Cauchy-Bunjakovki inequality. Norm. Metric functions. Gram-Schmidt method of orthogonalization. Linear mappings on unitary spaces. Unitary operators. Selfadjoint operators. Hermitian operators. Symmetric operators and assigned quadratic forms.

| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other<br>Consultations, project strategies |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[5]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 2 | Seminar paper | | Experiment | |
| Written exam | 3 | Oral exam | 2 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. S.Kurepa: Uvod u linearnu algebru, Školska knjiga, Zagreb, 1975.
2. K. Horvatić: Linearna algebra I, II I III, Sveučilište u Zagrebu, PMF, Matematički odjel, Zagreb, 1995.

*1.11. Recommended literature (when proposing the program)*

1. A. Aglić Aljinović, N. Elezović: Linearna algebra : zbirka zadataka, Zagreb : Element, 2003.
2. D. Bakić: Linearna algebra, Školska knjiga, Zagreb, 2008.
3. N. Bakić, A. Milas, Zbirka zadataka iz linearne algebre, PMF – Matematički odjel, Zagreb, 1996.
4. L. Čaklović: Zbirka zadataka iz linearne algebre, Školska knjiga, Zagreb, 1976.
5. J. Dieudonne: Linearna algebra i elementarna geometrija, Školska knjiga, Zagreb, 1977.
6. J. Hefferon, *Linear Algebra*, http://joshua.smcvt.edu/linearalgebra
7. S.Kurepa: Konačnodimenzionalni vektorski prostori, Liber, Zagreb, 1992.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[5] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Calculus III | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Elective | |
| Year | 2. | |
| Credit values and modes of instruction | ECTS credits / student workload | 7 |
| | Hours (L+E+S) | 45+45+0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

The aim of the course is to familiarize students with the basic concepts, results and methods of the differential and integral calculus real-valued functions and vector functions of more real variables. This course aims to give students the basic knowledge about:

- Euclidean spaces,
- sequence convergence in $R^n$
- real functions of several variables; continuity and limit of function,
- differential calculus and its application,
- implicit function theorem,
- multiple Riemann integral and application,
- vector functions,
- curves,
- line integral,
- surface integral,
- functions of bounded variation,
- Green's theorem.

*1.2. Course prerequisite*

None.

*1.3. Expected outcomes for the course*

After taking this course students will be able to:

- analyse the convergence of sequences and series in $R^n$
- (A6, B6, D6, E5, F5)
- describe the algebraic, metric and topological structure of the Euclidean space $R^n$
- (A6, B6, D6, E5, F5)
- investigate the boundary value of the vector function of multiple real variables and its continuity and other properties (A6, B6,D6, E5, F5)
- calculate partial derivations of the function of multiple variables (A6, B6, D6, E5, F5)
- apply and understand a differential calculus in geometry and in the test of the properties of the explicit, implicit and parametric functions (A6, B6, D6, E5, F5)
- determine Riemann's integral function of multiple variables and curve and surface integrals (A6, B6, D6, E5, F5)
- analyse fundamental concepts of differential and integral account of real and vector functions of multiple variables, such as the continuity of function, limes, partial derivation and function differentials, and multiple, curved and surface integral (A6, B6, D6, E5, F5)
- mathematically prove validity of all procedures and formulas that are used within the course (A6, B6, D6, E6, F6)

*1.4. Course content*

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Continuity and limes of real and vector functions of one and more real variables. Sequences and Compactness in R^n. Continuous functions on compact. Differential and partial derivations. Continuously Differentiated Functions and Schwarz's Theorem. Medium theorem value. Theorem on implicit functions. Theorem on inverse mapping. Taylor's theorem. Extremes. Double and multiple Riemann integral. Fubini's theorem and functions defined by integral. Curve. Curve integrals. Surface integrals. Functions of bounded variations. Vector and scalar fields. Green's theorem.

| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[6]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 2,5 | Seminar paper | | Experiment | |
| Written exam | 2,5 | Oral exam | 1,5 | Essay | | Research work | |
| Project | | Continuous assessment | 0,5 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. S. Kurepa: Matematička analiza III, Tehnička knjiga, Zagreb (više izdanja)
2. Š. Ungar: Matematička analiza u Rn, Golden Marketing-Tehnička knjiga, Zagreb 2005

*1.11. Recommended literature(when proposing the program)*

1. S. Mardešić: Matematička analiza u n-dimenzionalnom realnom prostoru, I. dio, Školska knjiga, Zagreb 1991.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13.Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[6] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Differential equations | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Elective | |
| Year | 2. | |
| Credit values and modes of instruction | ECTS credits / student workload | 6 |
| | Hours (L+E+S) | 30+30+0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

Course objective is to get students acquainted with the basics of the theory of ordinary differential equations.

In order to achieve that, the following units are presented to students:

- ordinary differential equations of the first order: the existence and uniqueness of the solution,
- types of first order differential equation and their solving methods: equations with separated variables, homogeneous and exact equations, linear, Bernoulli, Ricatti and Lagrange equations,
- ordinary differential equations of higher order: equations solvable by the highest derivation, linear homogeneous and nonhomogeneous equations and equations with constant coefficients,
- systems of differential equations: normal systems and systems of linear differential equations, existence and uniqueness of solutions,
- partial differential equations: concept, classification and basic examples.

*1.2. Course prerequisite*

None.

*1.3. Expected outcomes for the course*

After completing this course (attending the lectures and passing the final exam), the students should be able to:

- analyse the differential equation and determine the existence and uniqueness of the solution (A6, B6, E4, F5),
- differentiate and understand the types of first-order differential equations and apply different methods of solving accordingly (A6, B6, E4, F5),
- analyse higher order differential equations and apply different methods of their solving (A6, B6, E4, F5),
- solve systems of differential equations and analyze their solutions (A6, B6, E4, F5),
- apply differential equations in physics (A7, B6, E4, F5)
- analyse and solve some examples of partial differential equations with different initial and marginal conditions (A6, B6, E4, F5),
- mathematically prove the foundations of procedures and formulas used in this course (A6, B6, E4, F5).

*1.4. Course content*

Ordinary differential equations of the first order: the concept of solution, the field of directions, the integral curves, the theorem of existence and uniqueness of the solution; elementary methods of solving; equations with separated variables, homogeneous equations, linear equations, exact equations and equations that are reduced to them by integrating factor. Ordinary differential equations of higher order: equations solved by the highest derivation; systems of ordinary differential equations, reduction to the normal system of the first order; the theorem of existence and uniqueness of the solution. Linear differential equations and equations with constant coefficients; the theorem of existence and uniqueness for the system of linear equations, the method of variation of constants. Partial differential equations, classification of linear differential equations of the second order and canonical form. Basic equations of mathematical physics. Wave Equation, Heat Equation, and Laplace Equation.

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| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[7]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 1 | Seminar paper | | Experiment | |
| Written exam | 2.5 | Oral exam | 1.5 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. Pontrjagin: Obyknovennye differencialnye uravnenina, Nauka, Moskva, 1970.
2. G. Birkhoff, G. C. Rota: Ordinary differential equations, Blaisdell, Waitham, Mass, 1969.
3. Shair Ahmad, Antonio Ambrosetti: A Textbook on Ordinary Differential Equations, Springer, 2014.

*1.11. Recommended literature (when proposing the program)*

1. C. R. Wylie: Differential equations, Mc Graw Hill, New York , 1979.
2. I. Aganović, K. Veselić: Linearne diferencijalne jednadžbe, Element, Zagreb, 1997.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[7] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Combinatorics | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Elective | |
| Year | 3. | |
| Credit values and modes of instruction | ECTS credits / student workload | 5 |
| | Hours (L+E+S) | 30 + 30 + 0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The main course objective is to get students acquainted with the combinatorial way of thinking and proving. For this purpose it is necessary within the course to:

- describe and compare different forms of the pigeonhole principle and its generalization,
- analyse the fundamental counting principles of elements of finite sets and combinatorial countings,
- define binomial and multinomial coefficients and analyse their properties,
- define multiplicative functions and analyse examples of multiplicative functions,
- define and differ some recurrence problems and analyse methods for solving the problems,
- define and compare some combinatorial structures.

### *1.2. Course prerequisite*

None.

### *1.3. Expected outcomes for the course*

After completing the course, the students are expected to:

- analyse and differentiate applications of the counting principles or forms of the pigeonhole principle (A5, B6, C6, D6, E4, F5),
- give an explanation for the chosen counting principle or the form of the pigeonhole principle and apply an adequate method while solving problems (A5, B6, C5, D5, E4, F5),
- describe multiplicative functions and analyse examples of multiplicative functions (A4, B5, C5, D5, E4, F5),
- analyse recurrence problems in solving combinatorial exercises while explaining used procedures (A5, B6, C5, D5, E4, F5),
- give an explanation for the use of binomial and multinomial coefficients in problem solving (A5, B6, C5, D5, E4, F5),
- formulate combinatorial interpretations for expressions while proving different statements (A6,B6,C6,D6,E4,F5),
- describe some combinatorial structures (A4, B5, C5, D5, E4, F5),
- mathematically prove validity of all procedures and formulas that are used within the course (A6, B6, C6, D6, E4, F5).

### *1.4. Course content*

The fundamental counting principles. The pigeonhole principle. Ramsey's theorem. Permutations and combinations of sets and multisets. Binomial and multinomial coefficients. The principle of inclusion and exclusion. Multiplicative functions. Recurrence relations. Generating functions. Some combinatorial structures.

| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other<br>Consultations, project strategies |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[8]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 2.5 | Seminar paper | | Experiment | |
| Written exam | 0.5 | Oral exam | 1 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. D.Veljan: Kombinatorika i diskretna matematika, Algoritam, Zagreb, 2001.
2. M. Cvitković, Kombinatorika, zbirka zadataka, Element, Zagreb, 2001.

*1.11. Recommended literature (when proposing the program)*

1. D. Žubrinić, Diskretna matematika, Element, Zagreb, 1997.
2. D. Veljan, Kombinatorika s teorijom grafova, Školska knjiga, Zagreb, 1989.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[8] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Euclidean Spaces | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Elective | |
| Year | 3. | |
| Credit values and modes of instruction | ECTS credits / student workload | 5 |
| | Hours (L+E+S) | 30+30+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Objective of this course is to introduce basic properties of Euclidean spaces, i.e. to:

- define basic terms and properties of affine and Euclidean spaces,
- analyse various forms of plane equation,
- analyse the intersection and the sum of k-dimensional planes, their dimensions and describe their relation,
- analyse analytic geometry of affine space,
- define affine coordinates and describe a transformation of coordinates,
- describe convex sets, define and distinguish parallelotopes and simplexes as subsets of an affine space,
- analyse affine transformations and their properties, including the analytic approach,
- analyse analytic geometry and isometries of Euclidean spaces,
- analyse the volume of parallelotopes and simplexes,
- define isometric operators and symmetry groups.

### *1.2. Course prerequisite*

None.

### *1.3. Expected outcomes for the course*

After completing this course students are expected to be able to:

- distinguish terms of affine and Euclidean spaces and apply and understand adequate methods while solving problems (A6, B5, C6, D6, E5, F5),
- determine the corresponding equation of k-dimensional plane in affine space (A5, B5, C6, E5, F4),
- distinguish mutual relations of k-dimensional planes and determine their intersection and sum in affine space (A6, B6, C5, D6, E5, F6),
- apply and understand analytic geometry of affine space and transformation of coordinates (A6, B6, C5, D5, E5, F5),
- classify basic convex sets in n-dimensional affine space and apply and understand adequate methods while solving problems (A5, B6, C6, D5, E5, F5),
- apply and understand properties of affine mappings while solving problems (A5, B6, C6, D5, E5, F5),
- analyse properties and mapping of n-dimensional Euclidean space, especially isometries of Euclidean space and isometric operators (A6, B6, C6, D5, E6, F6),
- apply and understand the properties, methods and formulas while solving problems (A6, B6, C5, D5, E5, F4),
- mathematically prove validity of procedures and formulas that are used within this courses (A7, B6, C6, D6, E5, F5)

### *1.4. Course content*

Definition of affine and Euclidean spaces. Affine subspaces (planes). The intersection and the sum of affine subspaces and their dimensions. Parallel planes. Coordinates. Transformation of coordinates. Equation of a hyperplane and a line. Convexity. Half spaces. Parallelotopes. Simplexes. Affine mappings. Translations.
Euclidean spaces. Distance between two points. Angle between two lines, and between a line and a k-dimensional plane. Orthogonal planes. Distance between a point and a k-dimensional plane. Angle between two planes. Volume of a parallelotope and a simplex. Isometries. Isometric operators. Group of isometries. Translations and central symmetry. Rotation. Decomposition of isometric theorem.

| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other<br>Consultations, project strategies |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[9]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 1.5 | Seminar paper | | Experiment | |
| Written exam | 1.8 | Oral exam | 1.1 | Essay | | Research work | |
| Project | | Continuous assessment | 0.6 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points. The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. S. Kurepa: Konačno-dimenzionalni vektorski prostori i primjene, Liber, Zagreb, 1992.
2. M. Polonijo et al., Euklidski prostori, skripta, http://web.math.hr/nastava/eukl/EP.pdf

*1.11. Recommended literature (when proposing the program)*

1. M. Audin, Geometry, Springer-Verlag, Heidelberg, 2002.
2. D. M. Bloom, Linear Algebra and Geometry, Cambridge University Press, Cambridge, 1988.
3. K. W. Gruenberg, A. J. Weir, Linear Geometry, Springer, New York, 1977.
4. P. J. Ryan, Euclidean and non-Euclidean Geometry – an analytic approach, Cambridge Univ. Press, Cambridge, 1991.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[9] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Mathematical logic | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Elective | |
| Year | 3. | |
| Credit values and modes of instruction | ECTS credits / student workload | 5 |
| | Hours (L+E+S) | 30+30+0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The main course objective is to get students acquainted with basic notions of mathematical logic. Logical inferring is the basis for mathematical reasoning. This course will acquaint the students with:

- formal mathematical logic
- separation of syntax and semantics and their relation, through basics of propositional and predicate logic
- substantial understanding of strict mathematical proofs, theorems and notions of mathematical objects, through formal deductive systems.

### *1.2. Course prerequisite*

None.

### *1.3. Expected outcomes for the course*

After completing this course, the students are expected to be able to understand and apply basic notions of mathematical logic:

- describe the notion of a formula and formulate interpretation of a formula in propositional and predicate logic (A6, B6, D5, E5, F6)
- formulate and analyse the notions of valid, satisfiable, refutable formula and contradiction, as well as implication and equivalence of formulas in propositional and predicate logic (A6, B6, D5, E5, F6)
- analyse expressability of logical connectives (A6, B6, D5, E5, F6)
- construct normal forms for formulas of propositional logic (A6, B6, D5, E5, F6)
- construct prenex normal forms for formulas of predicate logic (A6, B6, D5, E5, F6)
- formulate the notion of a proof and theorem in Hilbert formal system and natural deduction system, and describe the main corresponding metatheorems (A6, B6, D5, E5, F6)
- analyse and construct deductions in natural deduction system for propositional logic (A6, B6, D5, E5, F6)
- explain the role of mathematical logic in mathematics as a science, historical and intuitive importance of propositional logic and the reasons for introductions of stronger logical theories, especially first order logic (A6, B6, D5, E5, F6)
- describe the main metatheorems and limitations of first order logic (A5, B5, D5, E5, F6)
- mathematically prove foundations of the procedures and theoretical results used within this course (A6, B6, D5, E5, F6)

### *1.4. Course content*

Classical propositional logic: syntax and semantics. Logical connectives. Disjunctive and conjunctive normal form. Craig lemma. Validity tests.
Hilbert's formal system and natural deduction system: consistent and complete sets of formulas, deduction theorem, soundness theorem, completeness theorem, compactness theorem. Limitations of propositional logic.

First order logic: syntax and semantics. Prenex normal form. Truth trees. Main meta-theorems and limitations of first order logic.

| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other<br>Consultations |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[10]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 0.5 | Seminar paper | | Experiment | |
| Written exam | 2 | Oral exam | 1.5 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. M.Vuković: Matematička logika, Element, 2009.

*1.11. Recommended literature (when proposing the program)*

1. A.G.Hamilton: Logic for Mathematicians, Cambridge, University Press, 1988.
2. E.Mendelson: Introduction to Mathematical Logic, (D.van Nostrand Reihold Company,New York),1964.
3. Joel V.Robbin: Mathematical Logic, (W.A.Benjamin Inc.,New York),1969.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[10] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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| General information | | |
|---|---|---|
| Lecturer | | |
| Course title | Complex Analysis | |
| Program | Undergraduate Study Programme Physics | |
| Course status | Elective | |
| Year | 3. | |
| Credit values and modes of instruction | ECTS credits / student workload | 7 |
| | Hours (L+E+S) | 45+30+0 |

## 1. COURSE DESCRIPTION

*1.1. Course objectives*

The main objective of this course is to get students acquainted with:

- the properties of complex functions of complex variables
- the notion, properties and methods of computation of the curve integrals
- the notion of Laurent series and the Residue theorem.

*1.2. Course prerequisite*

None.

*1.3. Expected outcomes for the course*

After completing this course, the students are expected to be able to:

- apply the properties of complex functions of complex variable
- describe the notion of the curve integral and apply the methods of computation
- describe and explain the concept of Taylor and Laurent series and classify the singularities of a given function
- state and explain the Residue Theorem and apply the theorem to calculate integrals
- mathematically prove validity all the procedures and formulas used within the course.

*1.4. Course content*

Holomorphic functions. Cauchy- Riemann's conditions. Elementary functions. Cauchy's Theorem. Curve index. Cauchy's Integral Formula. Morera's Theorem. Function series. Derivation and integration of function series. Power series. Liouville's Theorem. Laurent series. Singularities and their classification. The Residue Theorem and its applications. Poles of meromorphic finctions. Rouche's Theorem. Open Map Theorem. Maximum modules principle. Schwartz's Lemma.

| | | |
|---|---|---|
| *1.5. Modes of instruction* | ☒lectures<br>☐seminars and workshops<br>☒exercises<br>☒e-learning<br>☐field work | ☒independent work<br>☒multimedia and the internet<br>☐laboratory<br>☐tutorials<br>☐other<br>Consultations, project strategies |
| *1.6. Comments* | | |

*1.7. Student requirements*

Students are required to attend classes and actively participate in them. They are required to achieve a certain number of points during the semester and to pass the final exam (details will be described in the course curriculum).

*1.8. Evaluation of assessment*[11]

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance & class participation | | | 2 | Seminar paper | | Experiment | |
| Written exam | 2 | Oral exam | 2 | Essay | | Research work | |
| Project | | Continuous assessment | 1 | Presentation | | Practical work | |
| Portfolio | | | | | | | |

*1.9. Assessment and evaluation of students' work during the semester and on the final exam*

Students' work will be evaluated and assessed during the semester (e.g. preliminary exams, tests, seminars, online tests, homework etc.) and on the final exam.
Total number of points student can earn during the semester is 70, while on the final exam student can achieve 30 points.
The detailed elaboration of monitoring and evaluation of students' work will be described in the course curriculum.

*1.10. Required literature (when proposing the program)*

1. H. Kraljević, S. Kurepa, Matematička analiza IV (funkcije kompleksne varijable), Tehnička 2. knjiga, Zagreb, 1984.
2. S. Lang, Complex Analysis, Springer, 2003.

*1.11. Recommended literature (when proposing the program)*

1. M. J. Albowitz, A. S. Fokas,Complex variables, Introduction and application, Cambridge University Press, 2003.
2. J. Bak, D. J. Newman, Complex Analysis, Springer, 2010.

*1.12. Number of copies of required literature in relation to the number of students currently attending classes of the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*1.13. Quality assurance which ensure acquisition of knowledge, skills and competencies*

In the last week of this course, the students will evaluate the quality of the lectures. Additionally, the analysis of the exam results will be conducted.

[11] **IMPORTANT**: Fill in the appropriate number of points for each of the chosen categories so that the sum of the allocated points corresponds to the course credit value. Add new categories, if necessary.

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**List of compulsory and elective courses and/or modules with teaching hours required and ECTS credits allocated**

**- Computer Science**

| LIST OF MODULES/COURSES | | | | | | | |
|---|---|---|---|---|---|---|---|
| Semester: 2 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS[1] |
| All | Programming | | | | | | C |
| Semester: 3 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS |
| Comp. Sci. | Multimedia systems | | 30 | 30 | 0 | 5 | E |
| Semester: 4 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS[4] |
| Comp. Sci. | Computer Architecture and Organization | | 30 | 30 | 0 | 5 | E |
| Semester: 5 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS[5] |
| Comp. Sci. | Computer Networks | | 30 | 30 | 0 | 5 | E |
| | Databases | | 30 | 30 | 0 | 5 | E |
| | Object-oriented Programming | | 30 | 30 | 0 | 5 | E |
| Semester: 6 | | | | | | | |
| Comp. Sci. | Data modeling | | 30 | 30 | 0 | 5 | E |
| | Operating Systems | | 30 | 30 | 0 | 5 | E |

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| URSE DESCRIPTION | | |
|---|---|---|
| Course instructor | Assoc. Prof. Ana Meštrović | |
| Name of the course | Programming | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Compulsory | |
| Year of study | 3. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

This course provides basic comprehension of approaches, concepts and methods in procedural programming and gives an introduction to modular program construction. The course covers topics including methods of algorithm development and implementation, using of language constructs in simple program coding and methods for code debugging. Further, the course covers topics regarding advanced programming techniques including separate compilation, interface/implementation design and coding, dynamic memory allocation, pointer manipulation, and recursion. The course familiarises the student with commonly used algorithms, using the C++ programming language.

*2. Course enrolment requirements*

There are no course enrolment requirements.

*3. Expected learning outcomes*

The student should become familiar with the:
- basic operation of the programming environment and computer literacy.
- Boolean expressions, variable types and
memory storage.

The student should learn:
- how to develop an algorithm and implementation to compute a mathematical function.
- to convert a set of Mathematical statements into a C++ Boolean expression.
- to develop an algorithm using programming language selection constructs.
- to develop an algorithm and implementation that repeatedly executes a sequence of steps.
- to debug a simple program and remove all syntax errors and all logic errors.
- to use preprogrammed functions to implement an algorithm.
- to implement a hierarchical design using methods/functions.
- to properly document code to a given standard.
- to develop and write a program that uses one or more array structures to store information.
- to develop and write a program that uses simple data files to store and retrieve information.
- advanced programming techniques including dynamic memory allocation, pointer manipulation, and recursion.

*4. Course content*

Historical survey of programming languages. Procedural and object-oriented languages. General or multipurpose languages. Special-purpose languages.

The software development process. Developing programs interactively. Concepts of imperative, structured programming. The notion of the algorithm.

Syntax and semantix of C++. Types, values and declarations: Names. Declarations. Type definitions. Numeric data types. Logical types. Character types. Enumeration types.

Expressions and statements: Expressions. Statements. Sequencing and control. Iterative statements.
Program structure: Procedural architecture. Alternative program architectures. Simple algorithms for search and sort. Parameters. Functions. Structured data: Arrays. Records. Strings. Files.
Dinamic memory allocation, pointer manipulation. Recursion.

| | | |
|---|---|---|
| *5. Manner of instruction* | ☒ lectures | ☒ individual assignments |
| | seminars and workshops | multimedia and network |
| | exercises | ☒ laboratories |
| | distance learning | mentorship |
| | fieldwork | other ____________________ |
| *6. Comments* | | |

*7. Student responsibilities*

Students are expected to:
attend classes regularly
make necessary preparations for classes
do practical work
pass two midterm exams and a final exam.

*8. Monitoring[15] of student work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 2 | Class participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | 0.5 | Continuous assessment | 1 | Report | | Practical work | 0.5 |
| Portfolio | | Discussion | | | | | |

*9. Assessment of learning outcomes in class and at the final exam (procedure and examples)*

*10. Mandatory literature (at the time of submission of study programme proposal)*

1. 1. Julijan Šribar, Boris Motik:
2. Demistificirani C++, Dobro upoznajte protivnika da biste njime ovladali, Element, Zagreb, 2001.

*11. Optional/additional literature (at the time of submission of the study programme proposal)*

1. Jesse Liberty, Teach Yourself C++ in 24 Hours, SAMS, 1999.
2. Leslie B.Wilson and Robert G.Clark: Comparative Programming Languages, Third Edition, Addison-Wesley, 2001.

*12. Number of assigned reading copies in relation to the number of students currently attending the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |

*13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences*

Quality of the course will be monitored and measured through the success of examinations and through the anonymous inquiry reflecting students opinions regarding the course.

| COURSE DESCRIPTION | | |
|---|---|---|
| Course instructor | Full Prof. Nataša Hoić-Božić, PhD | |
| Name of the course | Multimedia Systems | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Elective | |
| Year of study | 2. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

The objective of the course is for students to acquire basic knowledge of the process of digitalization of single media (text, graphics, audio, video) and possibilities of their integration in the web site according to the guidelines for responsive web design and using multimedia standards.

*2. Course enrolment requirements*

There are no course enrolment requirements.

*3. Expected learning outcomes*

After fulfilling all the obligations anticipated by the course, students are expected to be able to:

I1. Describe basic concepts of multimedia and multimedia elements, as well as principles and guidelines for web design and responsive design.

I2. Analyse different types of web sites according to the given guidelines for web design.

I3. Choose appropriate HTML tags and cascading style sheet elements (CSS) when creating web sites.

I4. Compare text and hypertext and design them for multimedia presentation elements by applying the HTML standards.

I5. Compare raster graphics (bitmaps) and vector graphics for print and web and create examples by applying appropriate colour models and file formats.

I6. Record, edit and adjust video and audio for web, choosing an appropriate compression standard.

I7. Embed the created samples of digitalised multimedia records for hypertext, graphics, audio and video into HTML documents.

I8. Create and publish a web site based on a designed navigation diagram, by integrating the created individual multimedia records, all in accordance with guidelines for responsive web design and using multimedia standards.

*4. Course content*

- Concept of multimedia and hypermedia, historical overview, application of multimedia, multimedia computer systems.
- Basic WWW concepts (HTTP, URL, HTML) and standards (HTML5) and cascading style sheets (CSS).
- Principles of web design. Graphic design, information design, interface design and navigation design. Responsive web design.
- Embedding text into computer and formatting textual content. Typography. Concepts of hypertext

and hypertextual interface elements. Application of text and hypertext on the web.

- Graphics: types of graphics (bitmaps and vector graphics), image digitalization, colour schemes, standards and graphics compression, web graphics.
- Sound digitalization. Basic patterns of audio content records, speech content, music content. Audio compression. Application of audio on the web.
- Properties and types of video. Uploading a video to a computer. Video compression and video standards. Application of video on the web.
- Basics of the development of multimedia presentations according to the ADDIE model. Application of models to design and creation of multimedia web sites.

| | | |
|---|---|---|
| *5. Manner of instruction* | ☒ lectures | ☒ individual assignments |
| | ☐ seminars and workshops | ☒ multimedia and network |
| | ☒ exercises | ☒ laboratories |
| | ☒ distance learning | ☐ mentorship |
| | ☐ fieldwork | ☐ other ____________________ |
| *6. Comments* | Classes are held in blended form, by combining classroom work, individual work outside the classroom and e-learning, using a learning management system (LMS). A detailed schedule with online lessons and classroom lectures will be defined in the syllabus. When they enrolinto this course, students will be instructed to use the tools available inthe LMS. | |

*7. Student responsibilities*

Student responsibilities for this course are as follows:

- Regularly follow course activities within the LMS and attend f2f classes taking place in the form of lectures, auditory and/or laboratory exercises.
- Participate in continuous assessment (theoretical and practical preliminary exams) and successfully pass them.
- Participate in discussions on a given topic on wiki (or another tool).
- Write an individual or group paper on a given topic and present it to lecturers and other students.
- Score at least 50% on the final exam.

A detailed scoring system for the course and passing scores for individual activities will be specified in the course syllabus.

*8. Monitoring[10] of student work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 1 | Class participation | 0.5 | Seminar paper | 1 | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Continuous assessment | 1 | Report | | Practical work | |
| Portfolio | | Discussion | 0.5 | | | | |

[7] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

| _9. Assessment of learning outcomes in class and at the final exam (procedure and examples)_ | | |
|---|---|---|
| • Discussion (on wiki or another tool) in which students jointly analyse web sites with respect to the specific criteria (I1, I2), e.g. they analyse one well designed and one poorly designed web site according to individual web design elements (graphical design, information design, interface design and navigation design etc.).<br>• Written or online assessment (theoretical preliminary exam) in which students demonstrate their understanding of theoretical concepts regarding multimedia and web (I3, I4, I5, I6). For example, students name the characteristics of hypertext, compare bitmaps and vector graphics, describe compression formats for audio, video, graphics etc. through multiple choice questions, fill in the blank questions and essay questions.<br>• Practical assessment on a computer (practical preliminary exam) in which students, based on instructions and samples provided, need to create their own samples by using an appropriate programming tool (I3, I4, I5, I6). For example, they need to create graphics, audio and video similar to the ones provided, as well as a HTML document formatted using CSS that will integrate all these elements.<br>• Group or individual seminar paper in the form of a multimedia web presentation and corresponding preparatory documentation according to the instructions and evaluation criteria (I7-I8) set in advance. For example, students design a web site and present it using a navigation diagram and page draft, create all multimedia records (hypertext, graphics, audio, video) according to multimedia standards and integrate them into a complete web-presentation created according to the rules of responsive web design (the lecturer evaluates the paper by using the criteria known to the students before starting the assignment). | | |
| _10. Mandatory literature (at the time of submission of study programme proposal)_ | | |
| 1. Vaughan, T. (2014). Multimedia: Making It Work, Ninth Edition 9th Edition, Berkeley: McGraw-Hill Osborne Media.<br>2. Hoić-Božić, N. (2015). Multimedijski sustavi, Online skripta s predavanjima u Moodle e-kolegiju<br>3. Beaird, J. Načela dobrog web dizajna, Site point (Dobar plan; Zagreb), 2012.<br>4. Niederst Robbins, J. (2018). Learning Web Design, 5th Edition (A Beginner's Guide to HTML, CSS, JavaScript, and Web Graphics), O'Reilly Media, http://www.learningwebdesign.com/<br>5. Hoić-Božić, N. (2018). Uvod u web dizajn, Online skripta s predavanjima u Moodle e-kolegiju. | | |
| _11. Optional/additional literature (at the time of submission of the study programme proposal)_ | | |
| 1. Osborn, T. (2018). Hello Web Design: Design Fundamentals and Shortcuts for Non-Designers<br>2. Appropriate software manuals | | |
| _12. Number of assigned reading copies in relation to the number of students currently attending the course_ | | |
| Title | Number of copies | Number of students |
| | | |
| | | |
| | | |
| _13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences_ | | |

Periodical evaluations will be made for the purpose of ensuring and continuously improving the quality of classes and study programme (as part of the activities of the Quality Assurance Committee at the Department of Informatics). In the last week of classes, students will evaluate the quality of classes using an anonymous questionnaire. Students' achievements in the course will also be analysed (percentage of students who passed the course and their average grade).

| **COURSE DESCRIPTION** | | |
|---|---|---|
| Course instructor | Full Prof. Ivo Ipšić, PhD | |
| Name of the course | Computer Architecture and Organization | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Elective | |
| Year of study | 2. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

The objective of the course is to introduce students to the basics of computer system organization and to the basic concepts of computer system operation.

*2. Course enrolment requirements*

There are no course enrolment requirements.

*3. Expected learning outcomes*

After fulfilling all the obligations anticipated by the course, students are expected to be able to:

- I1. Analyse the CPU mode of operation and instruction set.
- I2. Analyse principles of operation of different RISC and CISC processor architectures.
- I3. Evaluate computer performance and effects of computer architecture on its performance.
- I4. Critically argue about the proposed optimal configuration with respect to its performance and price.
- I5. Choose a software solution for efficient execution of the instruction set.
- I6. Adjust the software solution to the characteristics of functional components of the computer.
- I7. Write simple programmes using an assembler.

*4. Course content*

Classification of computer architecture. Von Neumann computer model. Structure of a simple microprocessor: control unit, arithmetic logic unit. Execution of instructions of a simplified microprocessor model. Microprogrammed and hardwired control unit. MIPS processor pipeline architecture. Memory systems. Cache. Virtual memory. Computer performance analysis. Input-output computer systems. Interrupt and exception handling. Multicore processors and graphics processing units. Examples of assemblers for 32 and 64-bit microprocessors.

| | | |
|---|---|---|
| *5. Manner of instruction* | ☒ lectures | ☒ individual assignments |
| | ☐ seminars and workshops | ☐ multimedia and network |
| | ☒ exercises | ☐ laboratories |
| | ☒ distance learning | ☐ mentorship |
| | ☐ fieldwork | ☐ other ____________________ |
| *6. Comments* | Classes are held by combining classroom work, computer laboratory work and individual work outside the classroom, using a learning management system (LMS). When they enrol into this course, students will be instructed to use the distance learning system. A detailed schedule with lectures and exercises will be defined in the syllabus. | |

| *7. Student responsibilities* |
|---|
| Student responsibilities for this course are as follows:<br>• Regularly attend classes, participate in all course activities and follow course activities within the distance learning system.<br>• Participate in continuous assessment (theoretical and practical preliminary exams and homework).<br>• Score at least 50% on the final exam.<br>A detailed scoring system for the course and passing scores for individual activities will be specified in the course syllabus. |

*8. Monitoring[17] of student work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 1 | Class participation | 0.5 | Seminar paper | | Experimental work | |
| Written exam | 1.5 | Oral exam | | Essay | | Research | |
| Project | | Continuous assessment | 2 | Report | | Practical work | |
| Portfolio | | | | | | | |

*9. Assessment of learning outcomes in class and at the final exam (procedure and examples)*

- Online assessment (homework) in which students, e.g. through multiple choice questions, fill in the blank questions and essay questions, list the characteristics of RISC and CISC processor architecture, describe the process of executing certain instructions in the microprocessor and analyse the status of the microprocessor during the execution. Through essay questions and fill in the blank questions, students demonstrate their knowledge of basic concepts and standards related to performance measurements for different computer subsystems. (I1-I3)
- Practical assessment (online preliminary exam), in which students complete problem-solving tasks, demonstrating the use of synthetic tests and analysing the results obtained, based on which they identify key architecture components that affect test results and potential performance bottlenecks. Based on the results, they propose potential alternatives and argue about their justification in relation to the expected increase in performance with respect to price. (I3, I4)
- Assessment (preliminary exam) in which students complete problem-solving and programming tasks using an assembler. For example, they analyse a programme segment consisting of several instruction sets and determine the state of the processor (registers, stack etc.) during the execution of such instructions. By analysing the execution of given instructions, they propose time sequence of the instructions that will enable efficient execution of such instructions. (I5, I6)
- Assessment (final exam) in which students complete problem-solving and programming tasks using an assembler, e.g. they write a simple program using an assembler, demonstrating they know how to use input-output devices. (I7)

*10. Mandatory literature (at the time of submission of study programme proposal)*

1. S. Ribarić. "Građa računala”, Algebra d.o.o., Zagreb, 2011.
2. J. L. Hennessy, D. A. Patterson. "Computer Organization and Design MIPS Edition: The Hardware/Software Interface", 5th edition, Morgan Kaufmann Pub., San Mateo, 2014.

[8] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the

course. Use empty fields for additional activities.

| | | |
|---|---|---|
| 3. Scripts, presentations and other learning material available in the e-course. | | |
| *11. Optional/additional literature (at the time of submission of the study programme proposal)* | | |
| | | |
| *12. Number of assigned reading copies in relation to the number of students currently attending the course* | | |
| Title | Number of copies | Number of students |
| | | |
| | | |
| | | |
| *13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences* | | |
| Periodical evaluations will be made for the purpose of ensuring and continuously improving the quality of classes and study programme (as part of the activities of the Quality Assurance Committee at the Department of Informatics). In the last week of classes, students will evaluate the quality of classes using an anonymous questionnaire. Students' achievements in the course will also be analysed (percentage of students who passed the course and their average grade). | | |

| **COURSE DESCRIPTION** | | |
|---|---|---|
| Course instructor | Full Prof. Mario Radovan, PhD / Vedran Miletić, PhD | |
| Name of the course | Computer Networks | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Elective | |
| Year of study | 3. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

The objective of the course is for students to master basic knowledge about computer networks, Internet, web applications and protocols, as well as to acquire skills for using such knowledge.

*2. Course enrolment requirements*

A pass mark in Fundamentals of Informatics.

*3. Expected learning outcomes*

After fulfilling all the obligations anticipated by the course, students are expected to be able to:

I1. Classify and compare reference models of computer system network architecture and name the role of each layer within these reference models.

I2. Explain the method of operation of chosen services and protocols from individual layers of reference network architecture models.

I3. Analyse major Internet protocols using protocol documentation and software tools.

I4. Name challenges in the domain of computer network security and describe solutions for responding to such challenges.

I5. Apply protocols of Internet application layer using the appropriate software tools.

I6. Recognise and express development trends in the information and communications technology in the domain of computer networks.

*4. Course content*

- Basic terminology related to computer networks and the Internet. Network edge and network core. Basic properties of networks. History of computer networking and Internet development.
- Application layer. Web. Electronic mail. Domain Name System. Peer-to-peer applications. Web application development.
- Transport layer. Multiplexing and demultiplexing. Connectionless data transfer. Reliable data transfer. Connection-oriented data transfer. Congestion management.
- Network layer. Virtual circuit and datagram. Router. Packet forwarding and Internet addressing. Routing. Broadcast and multicast.
- Data link layer. Troubleshooting. Multiple access links and protocols. Switches and local area networks.
- Wireless and mobile networks. Wireless connections. Wireless local area networks. Internet access through mobile networks. Mobility.

| | | |
|---|---|---|
| *5. Manner of instruction* | ☒ lectures | ☒ individual assignments |

| | | |
|---|---|---|
| | ☐ seminars and workshops | ☐ multimedia and network |
| | ☒ exercises | ☒ laboratories |
| | ☒ distance learning | ☐ mentorship |
| | ☐ fieldwork | ☐ other ___________________ |
| *6. Comments* | Classes are held by combining classroom work and computer laboratory work, with the application of a learning management system (LMS). When they enrol into this course, students will be instructed to use the distance learning system. A detailed schedule with lectures and exercises will be defined in the syllabus. | |

*7. Student responsibilities*

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures, auditory and/or laboratory exercises.
- Complete problem-solving tasks as part of homework and hand in the solutions within the deadline.
- Answer questions and complete problem-solving tasks during auditory and/or laboratory exercises.
- Score at least 50% on the final exam.

A detailed scoring system for the course and passing scores for individual activities will be specified in the course syllabus.

*8. Monitoring[22] of student work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 1 | Class participation | 0.5 | Seminar paper | | Experimental work | 1 |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Continuous assessment | 1.5 | Report | | Practical work | |
| Portfolio | | | | | | | |

*9. Assessment of learning outcomes in class and at the final exam (procedure and examples)*

- As part of their homework, in the form of online assessment, students are required to hand in their files with solutions to problem-solving tasks, demonstrating their ability to set up a network model and/or required network service configuration by using a network simulator, network emulator and server and client applications (I3, I5).
- In laboratory exercises, students are required to take written or online assessment, in which they demonstrate their understanding of theoretical concepts necessary to complete programming tasks, e.g. through multiple choice questions, fill in the blank questions and essay questions (I2, I4). Following the written or online assessment, students are required to solve problem-solving tasks and hand in the files with solutions through online assessment, thus demonstrating their ability to set up a network model and/or required network service configuration by using a network simulator, network emulator and server and client applications (I3, I5).
- Written or online assessment in which students demonstrate their understanding of theoretical concepts related to computer networks and the Internet, e.g. through multiple choice questions, fill in the blank questions and essay questions (I1, I2, I4, I6).

9 IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

*10. Mandatory literature (at the time of submission of study programme proposal)*

1. Kurose, J. F. & Ross, K. W. Computer networking: a top-down approach. (Pearson, 2013).
2. Peterson, L. L. & Davie, B. S. Computer networks: a systems approach. (Morgan Kaufmann, 2012).
3. Scripts, presentations and other learning material available in the e-course.

*11. Optional/additional literature (at the time of submission of the study programme proposal)*

1. Bažant, A., Gledec, G., Ilić, Ž., Ježić, G., Kos, M., Kunštić, M., Lovrek, I., Matijašević, M., Mikac, B. & Sinković, V. Osnovne arhitekture mreža. (Element, 2014).
2. Halsall, F. Computer networking and the Internet. (Addison-Wesley, 2006).
3. Tanenbaum, A. S. & Wetherall, D. Computer networks. (Pearson/Prentice Hall, 2011).
4. Sterbenz, J. P. G. & Touch, J. D. High speed networking: a systematic approach to high-bandwidth low-latency communication. (Wiley, 2001).
5. Comer, D. Computer networks and Internets. (Pearson, 2015).
6. Comer, D. Internetworking with TCP/IP. (Pearson/Prentice Hall, 2013).

*12. Number of assigned reading copies in relation to the number of students currently attending the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |
| | | |

*13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences*

Periodical evaluations will be made for the purpose of ensuring and continuously improving the quality of classes and study programme (as part of the activities of the Quality Assurance Committee at the Department of Informatics). In the last week of classes, students will evaluate the quality of classes using an anonymous questionnaire. Students' achievements in the course will also be analysed (percentage of students who passed the course and their average grade).

| COURSE DESCRIPTION | | |
|---|---|---|
| Course instructor | Full Prof. Patrizia Poščić, PhD | |
| Name of the course | Databases | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Elective | |
| Year of study | 3. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

The objective of the course is for students to master basic knowledge about databases, with a focus on relational databases. This knowledge includes, but is not limited to, logical database design, relational algebra and non-procedural query language (SQL).

*2. Course enrolment requirements*

Previously taken course Mathematics 1.

*3. Expected learning outcomes*

After fulfilling all the obligations anticipated by the course, students are expected to be able to:

- I1. Explain basic terminology related to the database theory, as well as concepts of relational data model.
- I2. Compare query execution methods by using a theoretical query language and a database query language.
- I3. By applying logical database design methods, create or modify a given logical model, thus removing anomalies from databases.
- I4. Set (design) a development environment for a selected database management system by creating user rights and roles and ensuring a satisfactory database security level.
- I5. Based on a logical model, create a database using a selected database management system, as well as its basic objects and structures (e.g. tables, views, keys).
- I6. Determine the conditions of entity integrity and referential integrity in the implemented database.
- I7. By using the selected query language, modify the existing database and create simple and complex queries for information within the database.
- I8. Within a given programming environment, design a software solution based on a relational database.

*4. Course content*

Introduction to databases. Database concepts. Relational database. Relational algebra.

Operations in the relational model. Non-procedural languages for working with relational databases – SQL.

Integrity rules in relational data model. Concept of null value and incomplete information. Elements of dependency theory. Normalization; normal forms. Software for application development based on relational databases.

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| | | |
|---|---|---|
| *5. Manner of instruction* | ☒ lectures | ☒ individual assignments |
| | ☐ seminars and workshops | ☐ multimedia and network |
| | ☒ exercises | ☒ laboratories |
| | ☒ distance learning | ☐ mentorship |
| | ☐ fieldwork | ☐ other ____________________ |
| *6. Comments* | Classes are held by combining classroom work, computer laboratory work and individual work outside the classroom, using a learning management system (LMS). When they enrol into this course, students will be instructed to use the distance learning system. A detailed schedule with lectures and exercises will be defined in the syllabus. | |

*7. Student responsibilities*

Student responsibilities for this course are as follows:

- Regularly attend classes, participate in all course activities and follow course activities within the distance learning system.
- Participate in continuous assessment (theoretical and practical preliminary exams and quizzes).
- Score at least 50% on the final exam.

A detailed scoring system for the course and passing scores for individual activities will be specified in the course syllabus.

*8. Monitoring[23] of student work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 1 | Class participation | 0.5 | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Continuous assessment | 2 | Report | | Practical work | |
| Portfolio | | Discussion | | Individual assignments | 0.5 | | |

*9. Assessment of learning outcomes in class and at the final exam (procedure and examples)*

The set of learning outcomes is assessed through continuous assessment (a theoretical or practical preliminary exam and quizzes) and a written exam, accompanied by computer work.

- In the theoretical preliminary exam, students demonstrate their understanding of theoretical concepts related to databases and the relational data model (I1) and they correlate and compare different query execution methods by using a theoretical query language and a database query language (I2). E.g. explain the limitations of primary key or translate a given SQL query into relational algebra and vice versa.
- At the written exam, students create an appropriate logical data model based on a predefined conceptual model and by applying appropriate rules, and identify the normal form of the existing relational schema, and perform database normalization. E.g. translate an entity-relationship diagram into relational data model or normalize a given relational schema to third normal form. (I3)

[10] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the course. Use empty fields for additional activities.

- Students independently create a development environment for the database management system (including the distribution of user privileges and a satisfactory security level) on a computer. E.g. students independently and/or according to the instructions determine user groups and privileges for working with a database and define them on a computer. (I4)
- In the practical preliminary exam and/or quiz on a computer, students create a database using the database management system based on the created logical model. E.g. students independently create objects and structures within a database (relations, attributes, keys, indices, views etc.) on a computer. (I5)
- In the practical preliminary exam and/or quiz, students determine the conditions of entity integrity and referential integrity and implement them in a database. E.g. students independently create primary and foreign keys on a computer, as well as corresponding constraints. (I6)
- In the practical preliminary exam and/or quiz, students independently modify the existing database or create simple and complex queries in a database using a chosen query language. E.g. students independently add a new attribute to the existing relation, create a view of the existing relation or find all the information on students whose average grade in a given academic year was over 4.3. (I7)
- On a computer, students independently and/or according to the instructions create a software solution with user interface using a chosen tool, on the basis of a previously created database. E.g. on a computer, students independently create a complex report from the relational database or a user interface for working with the existing relational database, all using a chosen programming tool. (I8)

*10. Mandatory literature (at the time of submission of study programme proposal)*

1. C. J. Date (2012). Database Design and Relational Theory: Normal Forms and All That Jazz. O'Reilly Media.
2. C. J. Date (2015). SQL and Relational Theory: How to Write Accurate SQL Code. O'Reilly Media.
3. Poščić, P. (2018). Databases, scripts, presentations and other learning material available in the e-course.

*11. Optional/additional literature (at the time of submission of the study programme proposal)*

1. M. Varga (1994). Baze podataka; konceptualno, logičko i fizičko modeliranje podataka. DRIP, Zagreb.
2. M. Radovan (1993). Baza podataka - relacijski pristup i SQL. Informator, Zagreb.
3. Appropriate software manuals.

*12. Number of assigned reading copies in relation to the number of students currently attending the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |

*13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences*

Periodical evaluations will be made for the purpose of ensuring and continuously improving the quality of classes and study programme (as part of the activities of the Quality Assurance Committee at the Department of Informatics). In the last week of classes, students will evaluate the quality of classes using an anonymous questionnaire. Students' achievements in the course will also be analysed (percentage of students who passed the course and their average grade).

| **COURSE DESCRIPTION** | | |
|---|---|---|
| Course instructor | Assoc. Prof. Marina Ivašić-Kos, PhD | |
| Name of the course | Object-Oriented Programming | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Elective | |
| Year of study | 3. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

The objective of the course is for students to acquire basic knowledge about object-oriented paradigm and learn how to apply standard concepts of object-oriented paradigm in system modelling and implementation using a chosen object-oriented programming language.

The objective is to teach students how to independently analyse and specify requests, develop models and programs by using object-oriented approach to solve problem-solving tasks.

*2. Course enrolment requirements*

Previously taken courses Programming 1 and Programming 2.

*3. Expected learning outcomes*

After fulfilling all the obligations anticipated by the course, students are expected to be able to:

I1. Explain concepts related to object-oriented paradigm such as class, object, data privacy and encapsulation, constructors and destructors, relationships between classes, class hierarchy, abstraction, inheritance, polymorphism.

I2. Design and model basic class concepts such as constructors, member attributes and methods with defined visibility and present them using an appropriate diagram (class diagram, activity diagram or sequence diagram).

I3. Implement a class with concepts such as constructors, member attributes and methods using an appropriate programming language.

I4. Design and model concepts of an object-oriented model such as encapsulation, relations of association and class hierarchy, inheritance, overloading, polymorphism and present them using a class diagram.

I5. Implement concepts of an object-oriented model such as association and class hierarchy, inheritance, overloading, overriding and polymorphism using an appropriate programming language and based on a designed class diagram.

I6. Compare and analyse different model implementations in the object-oriented paradigm such as the use of standard operators, friends of a class and class methods.

I7. Apply skills and knowledge from object-oriented paradigm to solve problem-solving tasks.

*4. Course content*

- Introduction to object-oriented modelling and programming. Standards and specificities of a chosen object-oriented language (C++). Concepts related to object-oriented paradigm such as class, object, data privacy and encapsulation, constructors and destructors, relationships between classes, class hierarchy, abstraction, inheritance, overloading, polymorphism.

- Modelling of basic class concepts such as constructors, member attributes and methods with defined visibility by using UML structure diagrams (class diagrams, object diagrams).
- Definition of classes with member attributes and functions with defined visibility. Constructors and destructors. Overloading of constructors and functions. Use of basic system classes and functions, and user-defined classes. Dynamic class definition. Copy constructor and class references. Complex classes, class strings, vectors.
- Modelling changes in object state (activity diagram, statechart diagram) and object interaction (sequence diagram, communication diagram).
- Relations between classes. Inheritance: types and application of inheritance. Modelling and implementation of inheritance. Class hierarchy and multiple inheritance. Function overriding and function overloading. Abstract classes, polymorphism, virtual classes.
- Function and class templates. Operator overloading. Selected chapters from STL library.
- Examples and analysis of object-oriented models and implementation of solutions to problem-solving tasks from various fields of application.

| | | |
|---|---|---|
| _5. Manner of instruction_ | ☒ lectures | ☒ individual assignments |
| | ☐ seminars and workshops | ☐ multimedia and network |
| | ☒ exercises | ☒ laboratories |
| | ☒ distance learning | ☐ mentorship |
| | ☐ fieldwork | ☐ other ____________________ |
| _6. Comments_ | Classes are held in blended form, by combining classroom work, individual work outside the classroom and e-learning, using a learning management system (LMS). A detailed schedule with online lessons and classroom lectures will be defined in the syllabus. When they enrol into this course, students will be instructed to use the tools available in the system. | |

_7. Student responsibilities_

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures, auditory and/or laboratory exercises.
- Participate in continuous assessment (theoretical and practical preliminary exams).
- Design, create and present a solution to a problem-solving task (individually or in pairs) and score at least 50% on the final exam.

A detailed scoring system for the course will be specified in the course syllabus.

_8. Monitoring[21] of student work_

[7] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the

course. Use empty fields for additional activities.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 1 | Class participation | 0.5 | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | 1 | Continuous assessment | 1 | Report | | Practical work | 1.5 |
| Portfolio | | Discussion | | | | | |

*9. Assessment of learning outcomes in class and at the final exam (procedure and examples)*

- Written or online assessment (theoretical preliminary exam) in which students demonstrate their understanding of theoretical concepts of object-oriented paradigm and analyse different model implementations. (I1, I6)
- Practical assessment in which students, using UML diagram tools, create class diagrams containing concepts such as class hierarchy, association, inheritance, overloading, polymorphism and interaction diagrams or activity diagrams, according to the given specification and problem-solving task. (I2, I4)
- Practical assessment (practical preliminary exam) in which students, on a computer and using a given programming language, implement a given class diagram and interaction diagram, with concepts such as class hierarchy, abstraction, inheritance and associations between classes, overloading, polymorphism. (I3, I5)
- Final exam: Practical project assignment in which students apply their skills and knowledge from the field of object-oriented paradigm to solve problem-solving tasks related to the topic of their choice, according to the instructions and evaluation criteria set in advance. (I7)

*10. Mandatory literature (at the time of submission of study programme proposal)*

1. Robert Lafore: Object-Oriented Programming in C++ (4th Edition), eBook, pdf, 2001.
2. Bjarne Stroustrup: The C++ Programming Language, 4th Edition, Addison-Wesley; 2013, pdf.
3. B. Stroustrup: Programming -- Principles and Practice Using C++ (Second Edition), Addison-Wesley, 2014.
4. Grady Booch: Object-Oriented Analysis and Design with Applications (3rd Edition), 2007, pdf.
5. M. Ivašić-Kos: Objektno progamiranje – C++, on-line prezentacije predavanja, zadaci i primjeri riješenih zadataka, Moodle e-knjiga, 2018.
6. M. Ivašić-Kos: Objektno modeliranje – UML, on-line prezentacije predavanja, zadaci i modeli različitih problemskih situacija, Moodle e-knjiga, 2018.

*11. Optional/additional literature (at the time of submission of the study programme proposal)*

1. Tony Gaddis: Starting Out with C++ from Control Structures to Objects (9th Edition), 2017.
2. Erich Gamma: Design Patterns: Elements of Reusable Object-Oriented Software, 2009, pdf.
3. Robert C. Martin: Clean Code: A Handbook of Agile Software Craftsmanship, 2015.
4. Effective Modern C++: 42 Specific Ways to Improve Your Use of C++11 and C++14, Scott Meyers, 2014.
5. B. Lippman: C++ Primer (5th Edition), Stanley, 2013, pdf.

*12. Number of assigned reading copies in relation to the number of students currently attending the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |

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*13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences*

Periodical evaluations will be made for the purpose of ensuring and continuously improving the quality of classes and study programme (as part of the activities of the Quality Assurance Committee at the Department of Informatics). In the last week of classes, students will evaluate the quality of classes using an anonymous questionnaire. Students' achievements in the course will also be analysed (percentage of students who passed the course and their average grade).

| COURSE DESCRIPTION | | |
|---|---|---|
| Course instructor | Full Prof. Mile Pavlić, PhD | |
| Name of the course | Data Modelling | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Elective | |
| Year of study | 3. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

The objective of the course is to teach students how to analyse business documentation and interview users, and how to create data models and logical schemas of relational databases.

*2. Course enrolment requirements*

There are no course enrolment requirements.

*3. Expected learning outcomes*

After fulfilling all the obligations anticipated by the course, students are expected to be able to:

I1. Compare different methodologies and tools for conceptual data modelling.

I2. Analyse business documents of a company, independently and/or by interviewing business users and document it according to specific criteria.

I3. Create a conceptual data model.

I4. Revise a conceptual data model and create a logical data model using basic principles of normalization process.

I5. Master basic concepts of organization and apply methods and techniques to the design of organisation and adjust information system.

*4. Course content*

- Information system design, methods and tools for data modelling, MIRIS - Information Systems Development Methodology, project realization
- abstraction
- entity-relationship method, entity-relationship diagram (ERD), entities, relationships, attributes, cardinality, candidate for entity type key
- limitations over data model
- translation of ERD into relational data model
- basic principles of normalization
- metamodelling
- basic concepts of organization theory
- methods and techniques of organization design
- coordination of information and organization systems

- analysis of organization system documentation data and content

| | | |
|---|---|---|
| *5. Manner of instruction* | ☒ lectures | ☒ individual assignments |
| | ☐ seminars and workshops | ☐ multimedia and network |
| | ☒ exercises | ☐ laboratories |
| | ☒ distance learning | ☐ mentorship |
| | ☐ fieldwork | ☐ other ____________________ |
| *6. Comments* | Classes are held by combining classroom work and individual work outside the classroom, using a learning management system (LMS). When they enrol into this course, students will be instructed to use the distance learning system. A detailed schedule with lectures and exercises will be defined in the syllabus. | |

*7. Student responsibilities*

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures, auditory and/or laboratory exercises.
- Participate in continuous assessment and achieve the number of credits equal to or higher than the passing score (if any).
- Participate in practical problem-solving tasks and achieve the number of credits equal to or higher than the passing score (if any).
- Individually or in teams, make a project and present it to the lecturer, and achieve the number of credits equal to or higher than the passing score (if any).
- Score at least 50% on the final exam.

A detailed scoring system for the course and passing scores for individual activities will be specified in the course syllabus.

*8. Monitoring[16] of student work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 1 | Class participation | 0.5 | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | 1 | Essay | | Research | |
| Project | 1.5 | Continuous assessment | | Report | | Practical work | |
| Portfolio | | | | | | | |

*9. Assessment of learning outcomes in class and at the final exam (procedure and examples)*

- Written or online assessment (theoretical preliminary exam) in which students demonstrate their understanding of theoretical concepts from the field of data modelling (I1, I3, I4, I5), e.g. students list the characteristics of different methodologies for conceptual data modelling through multiple choice questions, fill in the blank questions and essay questions.
- Practical problem-solving task in which students need to design a data model by applying appropriate methods and tools (I3, I4). For example, design a data model for the document "Travel

[8] IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the

course. Use empty fields for additional activities.

Order" using entity-relationship method and revise it using normalization principles.

- A project in which students, individually or in groups, need to choose methods for the collection of user requirements, create models and project documentation. Documentation needs to contain entity-relationship diagrams and a relational database schema (I2, I3, I4). Students present their solution to the lecturer. For example, for a chosen system (e.g. Student Service), students need to collect user requirements, analyse the documentation, create entity-relationship diagrams, translate them to relational database model and present their solutions to the lecturer.

*10. Mandatory literature (at the time of submission of study programme proposal)*

1. Scripts, presentations and other learning material available in the e-course.
2. Pavlić, M., Oblikovanje baza podataka, Odjel za informatiku, Sveučilište u Rijeci, Rijeka, 2011.
3. Pavlić, M., Informacijski sustavi, Školska knjiga, Zagreb, 2011.

*11. Optional/additional literature (at the time of submission of the study programme proposal)*

1. Valacich J. S., George J. F Modern Systems Analysis and Design. 8th ed. Pearson Education, Inc, 2017.
2. Pavlić, M., Jakupović, A., Čandrlić, S. Modeliranje procesa, Odjel za informatiku, Sveučilište u Rijeci, Rijeka, 2014.
3. Batini, C., Ceri, S., Navathe, SB., Conceptual Database Design: An Entity-relationship Approach, Benjamin/Cummings Publishing Company, 1992.
4. Elmasri, R., Navathe, S., Fundamentals of database systems. Addison-Wesley Publishing Company, 2010.

*12. Number of assigned reading copies in relation to the number of students currently attending the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |
| | | |

*13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences*

Periodical evaluations will be made for the purpose of ensuring and continuously improving the quality of classes and study programme (as part of the activities of the Quality Assurance Committee at the Department of Informatics). In the last week of classes, students will evaluate the quality of classes using an anonymous questionnaire. Students' achievements in the course will also be analysed (percentage of students who passed the course and their average grade).

| URSE DESCRIPTION | | |
|---|---|---|
| Course instructor | Assoc. Prof. Božidar Kovačić, PhD | |
| Name of the course | Operating Systems | |
| Study programme | Undergraduate Study Programme Physics | |
| Status of the course | Elective | |
| Year of study | 3. | |
| ECTS credits and manner of instruction | ECTS credits | 5 |
| | Number of class hours (L+E+S) | 30+30+0 |

*1. Course objectives*

The objective of the course is for students to acquire basic knowledge about operating systems and processes within operating systems, about basic concepts related to operating systems – process, process adjustment mechanisms, data management, memory management, and to acquire knowledge and skills for advanced use of operating systems.

*2. Course enrolment requirements*

There are no course enrolment requirements.

*3. Expected learning outcomes*

After fulfilling all the obligations anticipated by the course, students are expected to be able to:

I1. Name types of operating systems and explain basic tasks of operating systems with respect to their structure.

I2. Interpret program execution with the application of processes and threads, and link processes and threads to execution states.

I3. Analyse mutual exclusion mechanisms for processes and threads, and apply appropriate mutual exclusion mechanisms to problem solving, i.e. coordinating the simultaneous operation of processes and threads.

I4. Analyse memory management strategies and choose an appropriate memory management strategy for a specific problem-solving task.

I5. Analyse types of file systems and choose an appropriate file system according to the given system specifications.

I6. Link parts of operating system and hardware used for managing input-output units.

I7. Analyse security mechanisms in operating systems and justify the use of basic and additional protection functionalities for a specific operating system.

*4. Course content*

- Introduction to operating systems: development of operating systems, basic tasks of operating systems, structure of operating systems.
- Interaction (relationship) between an operating system and hardware, process management: process concurrency, synchronisation, delays, CPU management.
- Memory management: paging, segmentation, placement strategies, memory protection.

- Resource allocation, data management: working with files and directories.
- Managing input-output devices: driver, controller, interrupt processing.
- Role of security and protection in operating systems: security mechanisms, protection implementation in the operation of processes and threads.

| | | |
|---|---|---|
| *5. Manner of instruction* | ☒ lectures | ☒ individual assignments |
| | ☐ seminars and workshops | ☐ multimedia and network |
| | ☒ exercises | ☐ laboratories |
| | ☒ distance learning | ☐ mentorship |
| | ☐ fieldwork | ☐ other ____________________ |
| *6. Comments* | Classes are held by combining classroom work and computer laboratory work, with the application of a learning management system (LMS). A detailed schedule with lectures and exercises will be defined in the syllabus. When they enrol into this course, students will be instructed to use the distance learning system. | |

*7. Student responsibilities*

Student responsibilities for this course are as follows:

- Regularly follow course activities within the distance learning system and attend classes taking place in the form of lectures, auditory and/or laboratory exercises.
- Participate in continuous assessment (theoretical and practical preliminary exams) and successfully pass them.
- Write an individual or group paper on a given topic and present it to lecturers and other students.
- Score at least 50% on the final exam.

A detailed scoring system for the course and passing scores for individual activities will be specified in the course syllabus.

*8. Monitoring[15] of student work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Class attendance | 1 | Class participation | 0.5 | Seminar paper | 1 | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Continuous assessment | 1.5 | Report | | Practical work | |
| Portfolio | | Discussion | | | | | |

*9. Assessment of learning outcomes in class and at the final exam (procedure and examples)*

- In the written exam, students name types of operating systems, sketch parts and connections of operating systems and provide explanations of basic tasks of operating systems (I1).
- In the written exam, students write a program consisting of several processes and threads, explaining the results of program execution (I2).
- As their homework, students design a program that correctly coordinates a given system consisting

9 IMPORTANT: Enter the appropriate proportion of ECTS credits for each activity so that the total number of credits equals the ECTS value of the

course. Use empty fields for additional activities.

of several processes and threads by applying an appropriate mutual exclusion mechanism (I3).

- In the written exam, students complete a problem-solving task, in which they have a given memory management strategy, with certain limitations (I4).
- In the written or oral exam, students choose a file system and sketch the description of file placement on the drive (I5).
- In the written exam, students identify the activity of the operating system and hardware during the processing with input-output units (I6).
- In the written exam, students identify security and protection mechanisms of a given operating system (I7).
- Students write a group or individual seminar paper in which they analyse individual concepts of operating systems e.g. ones related to memory management, file systems, security mechanisms etc. according to the instructions and evaluation criteria set in advance. (I4-I7)

*10. Mandatory literature (at the time of submission of study programme proposal)*

3. Tanenbaum A., Modern Operating systems, Pearson, 2014.
4. Silberschatz, A., P.B. Galvin, G. Gagne, Operating System Concepts, 9th edition, John Wiley&Sons, New York, 2012.
5. Operacijski sustavi. Budin, L., Golub, M., Jakobović, D., Jelenković L. Element, Zagreb, 2010.

*11. Optional/additional literature (at the time of submission of the study programme proposal)*

1. Love R., Linux Kernel Development (3rd Edition), Addison-Wesley 2010.
2. Appropriate software manuals.

*12. Number of assigned reading copies in relation to the number of students currently attending the course*

| Title | Number of copies | Number of students |
|---|---|---|
| | | |
| | | |
| | | |

*13. Quality monitoring methods that ensure the acquisition of exit knowledge, skills and competences*

Periodical evaluations will be made for the purpose of ensuring and continuously improving the quality of classes and study programme (as part of the activities of the Quality Assurance Committee at the Department of Informatics). In the last week of classes, students will evaluate the quality of classes using an anonymous questionnaire. Students’ achievements in the course will also be analysed (percentage of students who passed the course and their average grade).

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**List of compulsory and elective courses and/or modules with teaching hours required and ECTS credits allocated**

**Optional Subject: Teacher Training**

| LIST OF MODULES/COURSES | | | | | | | |
|---|---|---|---|---|---|---|---|
| Semester: 3 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS[1] |
| | Educational psychology I | | 30 | 15 | 0 | 5 | E |
| | Introduction to linguistic culture | | 15 | 0 | 15 | 3 | E |
| Semester: 4 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS |
| | Educational psychology II | | 30 | 15 | 0 | 4 | E |
| Semester: 5 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS[4] |
| | Developmental psychology | | 30 | 15 | 0 | 5 | E |
| Semester: 6 | | | | | | | |
| MODULE | COURSE | COURSE INSTRUCTOR | L | E | S | ECTS | STATUS[5] |
| | Didactics I | | 30 | 15 | 0 | 4 | E |
| | Educating students with special needs | | 30 | 15 | 0 | 4 | E |

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| **Basic description** | | |
|---|---|---|
| ***Course coordinator*** | Prof. dr. sc. Anita Klapan | |
| ***Course title*** | DIDACTICS I | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 4 |
| | ***Number of hours (L+E+S)*** | 30 + 15 + 0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The aim of the course is to introduce students to the didactics concept and subject; to introduce theoretical and methodological foundations of didactics and teaching the basic concepts; to familiarize students with the learning systems of education and teaching with a critical and creative attitude towards the didactic theory and practice; to become familiar with the process of planning and programming classes (curricular approach) and to be able to create the curriculum, to meet with the theory of curriculum; to get acquainted with the elements of teaching situations and other educational situations; to become familiar with the process of communication in teaching; to learn about the elements that affect the educational atmosphere; to be able to transfer and interference in the knowledge of didactics in different situations of teaching and educational process; to motivate the research in didactics and teaching call.

### *1.2. Course enrolment requirements*

-

### *1.3. Expected course learning outcomes*

General competencies:
- ability to think critically and creatively;
- ability to analyze, synthesize and evaluate;
- ability to plan and organize;
- learning abilities through team and individual work;
- ability to manage information and present it

Specific competencies:
- to identify and explain didactics as a pedagogical discipline, and its relationship to other disciplines
- to identify and explain the relationship between didactics and methodology
- to define and explain basic didactic concepts
- to differentiate types of teachers and explain their impact on the teaching process
- to enumerate and analyze the perspectives of teaching
- to enumerate and describe the elements of the teaching process
- to properly define the goals and learning outcomes
- to list and explain didactic principles in the process of teaching and learning
- to create and analyze the performance program (curriculum) for one (selected) subject
- to create and analyze the preparation of the teaching unit

### 1.4. Course content

- basic learning concepts and learning systems
- types of teachers and teaching perspectives
- National Curriculum Framework
- planning and programming of teaching
- educational standards
- learning principles in teaching
- Current didactic problems and relevant documents

| | | |
|---|---|---|
| **1.5. Teaching methods** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☒ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☐ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☒ other |
| **1.6. Comments** | | |

### 1.7. Student's obligations

Requirements:
- regular attendance and active participation of students in all modes of teaching and learning
- make a presentation and review of the National Curriculum Framework
- create and analyze the performance program (curricula) for one subject
- knoweledge test
- read and study the compulsory literature and materials from lectures and exercises
- passing the written and oral exams

### 1.8. Evaluation of student's work

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.125 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1.475 | Report | | Practice | 1.4 |
| Portfolio | | | | | | | |

### 1.9. Assessment and evaluation of student's work during classes and on final exam

The student in the subject will be evaluated and assessed during the course. The total number of credits a student can get is 100 (evaluating the activities highlighted in the table).

### 1.10. Assigned reading (at the time of the submission of study programme proposal)

- Bognar, L., Matijević, M. (2002), Didaktika. Zagreb: Školska knjiga. (selected topics)
- Lavrnja, I. (1998), Poglavlja iz didaktike. Rijeka: Pedagoški fakultet. (selected topics)

### 1.11. Optional / additional reading (at the time of proposing study programme)

- 1. Bezić, K., Strugar, V. (1998). Učitelj za treće tisućljeće. Zagreb: HPKZ.
- 2. Jensen, E. (2003). Super-nastava. Zagreb: Educa.
- 3. Kyriacou, C. (1995). Temeljna nastavna umijeća. Zagreb: Educa.
- 4. Meyer, H. (2002). Didaktika razredne kvake.Rasprave o didaktici, metodici i razvoju škole. Zagreb: Educa.
- 5. Pastuović, N. (1999). Edukologija. Zagreb: Znamen.
- 6. Pratt, D.D. and Associates (1998). Five Perspectives on Teaching in Adult and Higher Education, Malabar, FL:
- Krieger Publishing.
- 7. Pratt, D.D. (1992) Conceptions of teaching. Adult Education Quarterly, 42(4), 203-220.
- 8. Terhart, E. (2001), Metode poučavanja i učenja. Zagreb: Educa

### 1.12. Number of assigned reading copies with regard to the number of students currently attending the course

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| ▪ Bognar, L., Matijević, M. (2002), Didaktika. Zagreb: Školska knjiga. | 17 | 100+ |

| | | |
|---|---|---|
| (selected topics) | | |
| ▪ Lavrnja, I. (1998), Poglavlja iz didaktike. Rijeka: Pedagoški fakultet. (selected topics) | 21 | 100+ |

**_1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences_**

The structure, scope and nature of defining the obligations of students allow the implementation of requirements for continuous monitoring of students in all aspects of its progress in the context of this case. Instrument monitoring and a basis for student assessment is monitoring protocol that will be for courses designed for each student.
The work of teachers will be evaluated by students, in the middle of the semester and at the end of the semester. For the purposes of the above evaluation the teacher is required to develop appropriate evaluation forms or use already existing, and to analyze the collected evaluation forms.
Students will be able to their suggestions and comments affect change or adjustment of the teaching process to their needs. Evaluation at the end of the semester is planned to assess the fulfillment of educational goals and aims, appropriate use of the proposed forms and methods of teaching during the semester.

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| **Basic description** | | |
|---|---|---|
| ***Course coordinator*** | Izv. Prof. dr. sc. Tamara Martinac Dorčić | |
| ***Course title*** | EDUCATING STUDENTS WITH SPECIAL NEEDS | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 4 |
| | ***Number of hours (L+E+S)*** | 30 + 15 + 0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

This course will introduce student with basic knowledge about different exceptionalities, functioning of students with different special needs and appropriate educational procedures in teaching children with special needs.

### *1.2. Course enrolment requirements*

Without requirements.

### *1.3. Expected course learning outcomes*

- Differentiate and describe different categories of children with special needs and of gifted students.
- Explain the possibilities of supporting students with difficulties in joining the educational system.
- Describe appropriate educational procedures in teaching children with special needs.
- Propose an example of an individualized educational program for students with disabilities.

### *1.4. Course content*

Who are children with special needs? Children with special needs and their environment. Intellectual disabilities. Specific learning disabilities. Communication, language and speech disorders. Emotional and behavior disorders. Hearing impairment. Visual impairment. Pervasive developmental disorders. Multiple disabilities. Physical disabilities and health impairments. Gifted children. Educating children with special needs.

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### *1.7. Student's obligations*

Regular attendance at classes, participation in activities, preparation of independent assignments and passing midterm exam.

### *1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.125 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 2.875 | Report | | Practice | |
| Portfolio | | Written assignments | | | | | |
| | | | | | | | |

### 1.9. Assessment and evaluation of student's work during classes and on final exam

Outcome 1 - tasks of objective and essay type on the midterm exam
Outcome 2 - objective and essay-type tasks on the midterm exam
Outcome 3 - essay-type tasks in the midterm exam, evaluation of independent work
Outcome 4 - evaluation of independent work

### 1.10. Assigned reading (at the time of the submission of study programme proposal)

- Ivančić. Đ. (2010). Diferencirana nastava u inkluzivnoj školi – procjena, poučavanje i vrednovanje uspješnosti učenika s teškoćama. Zagreb: Alka script.
- Kiš-Glavaš, L. (Ur.) (2012). Studenti s invaliditetom – opće smjernice. Zagreb: Sveučilište u Zagrebu.
- Woolfolk, A. (2016). Edukacijska psihologija. Jastrebarsko: Naklada Slap (poglavlje: Razlike među učenicima i potrebe učenja)

### 1.11. Optional / additional reading (at the time of proposing study programme)

Bouillet, D. (2010). Izazovi integriranog odgoja i obrazovanja. Zagreb: Školska knjiga.
Davis, R.D., Braun, E.M. (2001). Dar disleksije: zašto neki od najpametnijih ljudi ne znaju čitati i kako mogu naučiti. Zagreb: Alinea.
Cvetković-Lay, J., Sekulić-Majurec, A. (1998). Darovito je, što ću s njim? Zagreb: Alinea.
Igrić, Lj. (2015). Osnove edukacijskog uključivanja. Zagreb: Školska knjiga.
Kirk, S., Gallagher, J.J., Coleman, M.R.., Anastasiow, N. (2009). Educating exceptional children. Boston: Houghton Mifflin Company.
Krampač-Grljušić, A., Marinić, I. (2007). Posebno dijete – priručnik za učitelje u radu s djecom s posebnim obrazovnim potrebama. Osijek: Grafika.
Mićanović. M. (2008). Poučavanje učenika s autizmom – školski priručnik. Zagreb: Agencija za odgoj i obrazovanje.
Velki, T. (2018). Priručnik za rad s hiperaktivnom djecom u školi. Jastrebarsko: Slap.
Vicić. M. (1996). Metodika odgojno obrazovnog i rehabilitacijskog rada za djecu i mladež s mentalnom retardacijom. Zagreb: Hrvatsko društvo defektologa.

### 1.12. Number of assigned reading copies with regard to the number of students currently attending the course

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Ivančić. Đ. (2010). Diferencirana nastava u inkluzivnoj školi – procjena, poučavanje i vrednovanje uspješnosti učenika s teškoćama. Zagreb: Alka script. | 5 | 100 |
| Kiš-Glavaš, L. (Ur.) (2012). Studenti s invaliditetom – opće smjernice. Zagreb: Sveučilište u Zagrebu. | 1 | 100 |
| Woolfolk, A. (2016). Edukacijska psihologija. Jastrebarsko: Naklada Slap (poglavlje: Razlike među učenicima i potrebe učenja) | 5 | 100 |

### 1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences

Quality will be evaluated with questionnaire designed to evaluate course program, teaching methods and interaction with student at the end of the course. Also, it will be evaluated through discussion with student during the semester.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | doc. dr. sc. Barbara Rončević Zubković | |
| ***Course title*** | EDUCATIONAL PSYCHOLOGY I | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 2. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 5 |
| | ***Number of hours (L+E+S)*** | 30 + 15 + 0 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

The objective of this course is to get the students acquainted with different theories of learning and their implications for teaching. The aim is also that students understand information processing during complex cognitive skills and apply effective cognitive and metacognitive learning strategies.

### 1.2. Course enrolment requirements

### 1.3. Expected course learning outcomes

Students will be able to:
- describe and understand the principles of classical and operant conditioning in classroom settings
- describe and explain learning by observation in school
- describe and explain information processing theory of learning and constructivistic theory of learning
- describe and explain the possibilities of applying learning theories in teaching
- plan lecture according to constructivistic learning design
- apply some effective learning strategies (mnemonics, summarizing, asking questions)
- describe factors that affect knowledge evaluation
- describe and explain implications of different learning theories to teaching
- differentiate between norm-referenced and criterion-referenced testing

### 1.4. Course content

Classical conditioning in the classroom; Operant conditioning in the classroom; Modeling: Behavioral self-regulation and mentoring; Information processing theory; Constructivist learning theory; Cognitive and metacognitive strategies; Application of cognitive learning theories in teaching; Subjective assessment and objective measurement Knowledges; Alternative methods of knowledge assessment

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### 1.7. Student's obligations

Students are required to attend classes regularly and actively participate. They are required to complete written assignments based on classroom practices, and pass two written preliminary exams during semester and final exam.

### *1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.125 | Activity/Participation | 1.5 | Seminar paper | | Experimental work | |
| Written exam | 1.5 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 0.875 | Report | | Practice | |
| Portfolio | | | | | | | |

### *1.9. Assessment and evaluation of student's work during classes and on final exam*

Student work on the course will be evaluated and graded during classes and at the final exam. Total number points that a student can achieve during classes is 60, while in the final exam he can achieve 40 points.
A detailed elaboration of the method of monitoring and evaluating the work of students will be presented in the course syllabus.

### *1.10. Assigned reading (at the time of the submission of study programme proposal)*

Kolić-Vehovec, S. (1999). *Edukacijska psihologija*. Filozofski fakultet, Rijeka.
Vizek-Vidović, V., Vlahović-Štetić, V., Rijavec, M., Miljković, D. (2003). *Psihologija obrazovanja*. Zagreb: IEP.

### *1.11. Optional / additional reading (at the time of proposing study programme)*

1. Anderson, J.R. (1995). Learning and memory: an integrated approach. NY: John Wiley and Sons, Inc.
2. Brdar, I. i Rijavec, M. (1998). Što učiniti kada dijete dobije lošu ocjenu? Zagreb: IEP.
3. Desforges, C. (2001). Uspješno učenje i poučavanje: psihologijski pristupi. Zagreb: Educa.
4. Howe, M.J.A. (2002). Psihologija učenja: priručnik za nastavnike. Jastrebarsko: Naklada Slap.
5. Mackintosh, N.J. i Colman, A.M. (1995). Learning and skills. London: Longman.
6. Slavin, R.E. (2012). Educational psychology: Theory and practice. Boston: Allyn & Bacon.
7. Zarevski, P. (2007). Psihologija pamćenja i učenja. Jastrebarsko: Naklada Slap.
8. Woolfolk, A. (2016). Edukacijska psihologija. Jastrebarsko: Naklada Slap.

### *1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Kolić-Vehovec, S. (1999). *Edukacijska psihologija*. Rijeka: Filozofski fakultet. | 13 | 80 |
| Vizek-Vidović, V., Vlahović-Štetić, V., Rijavec, M., Miljković, D. (2003). *Psihologija obrazovanja*. Zagreb: IEP. | 22 | 80 |

### *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Course quality will be assessed based on students' achievement on written assignments, exams, and on students' evaluation of the course.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | doc. dr. sc. Barbara Rončević Zubković | |
| ***Course title*** | EDUCATIONAL PSYCHOLOGY II | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 2. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 4 |
| | ***Number of hours (L+E+S)*** | 30 + 15 + 0 |

## 1. COURSE DESCRIPTION

### 1.1. Course objectives

The aim of this course is that students become acquainted with different students' characteristics (abilities, motivation, personality traits) that contribute to individual differences in academic achievement among students. The students will also be acquainted with the effects of classroom social climate on academic performance, as well as with different approaches to classroom management.

### 1.2. Course enrolment requirements

### 1.3. Expected course learning outcomes

Students will be able to:
- Explain the construct of intelligence and its relation with academic achievement
- To design classroom lesson according to multiple intelligence theory
- Understand the relationship between self-concept and academic achievement
- Describe and understand motivational factors of learning outcomes
- Differentiate categories of social status in classroom and plan methods for social status improvement
- Understand components of student-teacher relationship
- Apply social skills in order to establish positive social interactions in classroom and change undesirable students' behaviors
- Understand different approaches to discipline management

### 1.4. Course content

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### 1.7. Student's obligations

Students are required to attend classes regularly and actively participate. They are required to complete written assignments based on classroom practices, and pass two written preliminary exams during semester and final exam.

### 1.8. Evaluation of student's work

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.125 | Activity/Participation | 0.575 | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 1.30 | Report | | Practice | |
| Portfolio | | | | | | | |

### 1.9. Assessment and evaluation of student's work during classes and on final exam

Written reports on completed assignments and colloquium are graded and all must be positively graded for taking the final exam; the pass criterion is 50% correct answers.

### 1.10. Assigned reading (at the time of the submission of study programme proposal)

Kolić-Vehovec, S. (1999). *Edukacijska psihologija*. Filozofski fakultet, Rijeka.
Vizek-Vidović, V., Vlahović-Štetić, V., Rijavec, M., Miljković, D. (2003). *Psihologija obrazovanja*. Zagreb: IEP.

### 1.11. Optional / additional reading (at the time of proposing study programme)

1. Kroflin, L., Nola, D. (ur.). (1987). Dijete i kreativnost. Zagreb: Globus.
2. Faber, A., Mazlish, E. (2000). Kako razgovarati s djecom da bi bolje učila. Zagreb: Mozaik knjiga.
3. Janković, J. (1996). Zločesti đaci genijalci. Zagreb: Alinea.
4. Neill, S. (1994). Neverbalna komunikacija u razredu. Zagreb: Educa.
5. Pintrich, P.R., Schunk, D.H. (1996). Motivation in education: Theory, research and application. Englewood Clifs, HJ: Prentice Hall.
6. Salovey, P., Sluyter, D.J. (1999). Emocionalni razvoj i emocionalna inteligencija. Pedagoške implikacije. Zagreb: Educa.
7. Winkel, R. (1996). Djeca koju je teško odgajati. Zagreb: Educa.
8. Woolfolk, A. (2016). Edukacijska psihologija. Jastrebarsko: Naklada Slap.

### 1.12. Number of assigned reading copies with regard to the number of students currently attending the course

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Kolić-Vehovec, S. (1999). *Edukacijska psihologija*. Rijeka: Filozofski fakultet. | 13 | |
| Vizek-Vidović, V., Vlahović-Štetić, V., Rijavec, M., Miljković, D. (2003). *Psihologija obrazovanja*. Zagreb: IEP. | 22 | |

### 1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences

Course quality will be assessed based on students' achievement on written assignments, exams, and on students' evaluation of the course.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | prof. dr. sc. Diana Stolac / doc. dr. sc. Anastazija Vlastelić / doc. dr. sc. Borana Morić-Mohorovičić | |
| ***Course title*** | Introduction to linguistic culture | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 2. | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 3 |
| | ***Number of hours (L+E+S)*** | 15+0+15 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

The basic goal of the course is to master the basics of language and spelling norms, both in written and in oral form. Special efforts are made to intoroduce students to the characteristics of the language of the profession and in the way they serve certain normative manuals (spelling, grammar, vocabulary, language advisor, etc.).
The course belongs to the humanistic segment of the student's education as a necessary segment of education. On the seminar part of the course in students develops skills usable in conducting other courses in which require students to have the competence of specific written and oral expression.

### *1.2. Course enrolment requirements*

-

### *1.3. Expected course learning outcomes*

- I1. independently interpret the basic features of the Croatian standard language
- I2. read the basic features of functional styles of the Croatian standard language and marginal styles in written and oral communication and apply them
- I3. identify and list (possible) solutions to normative deviations at all language levels in contemporary public language use, with special emphasis on the language of the profession
- I4. apply the acquired knowledge in writing (on the teaching material, presentations, blackboard) etc.) and oral expression (presentation, discussion, examination, etc.)
- I5. independently search linguistic manuals and websites and interpret the collected data.

### *1.4. Course content*

Language as a system and language as a standard (systemic norms and functional norms); standard language and its norms (I1).
Realization of standard language and functional styles (stylistic norms); elements of grammar (phonological, morphological, syntactic) and lexical norms; normative manuals (grammars, dictionaries, spellings) and manner their uses (I1, I2, I5).
Written expression; orthographic (spelling) norm; spelling rules; spelling manuals; computer spelling checker and how to use it; forms of written expression and text structure (I3, I4, I5).
Oral expression; orthoepic norm; values of spoken language (sentence melody, intonation, sentence accent); sentence as a communicative unit (statement); supra-sentence unity (text, discourse) (I3, I4, I5).
Language in the function of the profession; scientific style as one of the functional styles of the standard language; features and intra-stylistic stratifications (professional, popular science, scientific, school, etc.); professional terminology; terminological dictionaries; Croatian monolingual dictionaries; organization of a scientific / professional text (written and / or spoken); administrative style; administrative written forms (application, complaint, business letter, report, etc.) (I2, I3, I4, I5).

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☒ seminars and workshops<br>☐ exercises<br>☐ long distance education<br>☐ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☒other |
| ***1.6. Comments*** | | |

***1.7. Student's obligations***

Students are required to actively participate in all forms of teaching. They solve practical problems individually and in groups language tasks.

***1.8. Evaluation of student's work***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 0.75 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Sustained knowledge check | 2.25 | Report | | Practice | |
| Portfolio | | | | | | | |

***1.9. Assessment and evaluation of student's work during classes and on final exam***

- Written exercise 1 (I2, I3) - worksheet from the spelling norm - 5 points
- Written exercise 2 (I1, I2, I3, I5) - 30 points - the exercise consists of different types of tasks, the achievement of at least 40% of the achieved evaluation points is positively evaluated).
- Written exercise 3 (I3, I4, I5) - 40 points (the exercise is composed of different types of tasks, the achievement of at least 40% of the achieved evaluation points is positively evaluated).
- Homework (I2, I4) - 10 points (written work on a given topic from the teacher's discourse) (e.g. report, invitation to a parent meeting, CV, etc.).
- There is no final exam.

***1.10. Assigned reading (at the time of the submission of study programme proposal)***

• Badurina, Lada – Marković, Ivan – Mićanović, Krešimir, Hrvatski pravopis, Matica hrvatska, Zagreb, 2007.
• Frančić, Anđela –Hudeček, Lana – Milica Mihaljević, Normativnost i višefunkcionalnost u hrvatskome standardnom jeziku, Hrvatska sveučilišna naklada, Zagreb, 2005. ili 2007.
• Pravopis Instituta za hrvatski jezik i jezikoslovlje (http://pravopis.hr/).
• Silić, Josip, Funkcionalni stilovi hrvatskoga jezika, Disput, Zagreb, 2006.
• Težak, Stjepko – Babić, Stjepan, Gramatika hrvatskoga jezika, Školska knjiga, Zagreb (od) 71992.
• Veliki rječnik hrvatskoga standardnog jezika, Školska knjiga, 2015.
• www.prirucnik.hr
• http://savjetnik.ihjj.hr/

***1.11. Optional / additional reading (at the time of proposing study programme)***

• Anić, Vladimir, Rječnik hrvatskoga jezika, Novi Liber, Zagreb 31998. (ili koje ranije izdanje).
• Anić, Vladimir – Goldstein, Ivo, Rječnik stranih riječi, Novi Liber, Zagreb 1999.
• Barić, Eugenija – Lončarić, Mijo – Malić, Dragica – Pavešić, Slavko – Peti, Mirko – Zečević, Vesna – Znika, Marija, Hrvatska gramatika, Školska knjiga, Zagreb 1995.
• Frančić, Anđela – Petrović, B., Hrvatski jezik i jezična kultura, Visoka škola za poslovanje i upravljanje „Baltazar Adam Krčelić", Zaprešić, 2013.
• Govorimo hrvatski (jezični savjeti), www.hrt.hr.
• Hrvatski jezični portal, Novi Liber, http://hjp.novi-liber.hr/index.php?show=baza.
• Hrvatski na maturi, Institut za hrvatski jezik i jezikoslovlje, Zagreb, 2014., http://matura.ihjj.hr/
• Rječnik hrvatskoga jezika, ur. Jure Šonje, Leksikografski zavod - Školska knjiga, Zagreb 2000.
• Silić, Josip i Pranjković, Ivo, Gramatika hrvatskoga jezika, Zagreb, 2005.

| ***1.12. Number of assigned reading copies with regard to the number of students currently attending the course*** | | |
|---|---|---|
| *Title* | *Number of copies* | *Number of students* |
| **Fakultetska knjižnica ima dovoljan broj primjeraka obvezne i dopunske literature. Rječnici, gramatike, pravopisi i jezični savjetnici priručna su literatura i ne iznose se iz knjižnice. | | |
| Frančić, Anđela –Hudeček, Lana – Milica Mihaljević, Normativnost i višefunkcionalnost u hrvatskome standardnom jeziku, Hrvatska sveučilišna naklada, Zagreb, 2005. ili 2007. | 3 | |
| Silić, Josip, Funkcionalni stilovi hrvatskoga jezika, Disput, Zagreb, 2006. | 6 | |
| | | |
| | | |
| | | |
| | | |

***1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences***

The quality and success of the course will be assessed based on the success of the participants in the assignments and the exam. Students will assess the quality of the realization of the course with an anonymous questionnaire at the end of classes.

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| Basic description | | |
|---|---|---|
| ***Course coordinator*** | Prof. dr. sc. Sanja Smojver-Ažić | |
| ***Course title*** | DEVELOPMENTAL PSYCHOLOGY | |
| ***Study programme*** | Undergraduate Study Programme Physics | |
| ***Course status*** | Elective | |
| ***Year*** | 3. year | |
| ***ECTS credits and teaching*** | ***ECTS student 's workload coefficient*** | 5 |
| | ***Number of hours (L+E+S)*** | 30 + 15 + 0 |

## 1. COURSE DESCRIPTION

### *1.1. Course objectives*

Introduce student with basic knowledge about student development necessary for understanding process of teaching and education. Apply this knowledge in understanding educational process and understanding age appropriate tasks. Understanding normative development and individual differences. Development of skills for evaluation of age appropriate educational procedures in teaching children and adolescents.

### *1.2. Course enrolment requirements*

Without requirements.

### *1.3. Expected course learning outcomes*

After finishing this course student should be able to:
1. describe main aspects of development in children and adolescent
2. differentiate normative and individual development
3. understand individual differences between children and adolescents
4. analyze role of family and school in child and adolescent development and interaction between them

### *1.4. Course content*

Developmental theories. Physical growth and development. Puberty and biological changes. Cognitive development. Intellectual development and attainment. Moral development. Development of self-concept. Gender differences. Family and relations with parents. School and teachers. Peers relations and development. Developmental tasks in adolescence. Stress in adolescence. Adolescent adjustment.

| | | |
|---|---|---|
| ***1.5. Teaching methods*** | ☒ lectures<br>☐ seminars and workshops<br>☒ exercises<br>☐ long distance education<br>☒ fieldwork | ☒ individual assignment<br>☒ multimedia and network<br>☐ laboratories<br>☐ mentorship<br>☐ other |
| ***1.6. Comments*** | | |

### *1.7. Student's obligations*

They are expected regular attendance and active participation on class activities and write essay. Students are expected to apply for written examination during the semester. At the end of the semester students should pass written and oral exam.

### *1.8. Evaluation of student's work*

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course attendance | 1.2 | Activity/Participation | | Seminar paper | | Experimental work | |
| Written exam | 1 | Oral exam | | Essay | 0.80 | Research | |
| Project | | Sustained knowledge check | 1.00 | Report | | Practice | |
| Portfolio | | Written assignments | 1.00 | | | | |

### *1.9. Assessment and evaluation of student's work during classes and on final exam*

Student work will be evaluated through semester and on final exam. During the semester students can get 60 and on final exam 40 points. Detailed elaboration of monitoring and evaluation of students' work will be elaborated in the Syllabus.

### *1.10. Assigned reading (at the time of the submission of study programme proposal)*

Berk, L. E. (2008). Psihologija cjeloživotnog razvoja. Jastrebarsko: Naklada Slap (275-409) ILI
Vasta, R., Haith, M.M., Miller, S.A. (1998). Dječja psihologija. Jastrebarsko, Slap. (str. 24-62, 107-120,191-207, 253- 399, 457-467; 476-486; 488-644) ILI
Berk, L.E. (2015). Dječja razvojna psihologija.Jastrebarsko: Naklada Slap

### *1.11. Optional / additional reading (at the time of proposing study programme)*

Feinstein (2005). Tajne tinejdžerskog mozga. Naklada Kosinj.
Lacković-Grgin, K. (2006). Psihologija adolescencije. Jastrebarsko: Naklada Slap.
Lebedina Manzoni, M. (2006): Psihološke osnove poremećaja u ponašanju, Jastrebarsko: Naklada Slap
Siegel, D. (2017). Oluja u mozgu: snaga i svrha tinejdžerskog mozga. Split: Harfa.
Vizek-Vidović, V., Rijavec, M. Vlahović-Štetić, V., Miljković, D. (2003). Psihologija obrazovanja, Zagreb: IEPVern (41-140)
Woolfolk, A. (2016). Edukacijska psihologija. Jastrebarsko: Naklada Slap (25-103)
mrežne stranice i radovi iz časopisa po preporuci uz određenu temu

### *1.12. Number of assigned reading copies with regard to the number of students currently attending the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Vasta, R., Haith, M.M., Miller, S.A. (1998). Dječja psihologija. Jastrebarsko, Slap. (str. 24-62, 107-120,191-207, 253-399, 446-644) | 13 | 80 |
| Berk, L. E. (2008). Psihologija cjeloživotnog razvoja. Jastrebarsko: Naklada Slap (275-409) | 6 | 80 |
| Berk, L.E. (2015). Dječja razvojna psihologija.Jastrebarsko: Naklada Slap | 10 | 80 |

### *1.13. Quality monitoring methods which ensure acquirement of output knowledge, skills and competences*

Quality will be evaluated with questionnaire designed to evaluate course program, teaching methods and interaction with student at the end of the course. Also, it will be evaluated through discussion with student during the semester.