FACULTY OF PHYSICS AND ASTRONOMY
INSTITUTE OF PHYSICS

ECTS COURSE CATALOGUE

PHYSICS

SECOND DEGREE STUDIES

2014/2015

SEMESTER I:

SEMESTER II:

SEMESTER III:

SEMESTER IV:

PHYSICS LABORATORY II

Course code: **13.2-WF-FizD-PraFi2**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher directing the laboratory exercises**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					13
Laboratory	105	7	I	Grade	

COURSE AIM:

The goal of the advanced lab is to become familiar with experimental physics research. It is a test run as an experimental physicist with all responsibilities. This includes learning how to conduct meaningful experiments, mastering important experimental instrumentation and methods, analyzing data, drawing meaningful conclusions from them and presenting your results in a succinct manner. For this, you will conduct several experiments and error-analysis exercises.

ENTRY REQUIREMENTS:

- Physics laboratory I (General Physics Lab).
- calculus.

COURSE CONTENTS:

Experiments at an advanced level:
- Study of natural background radiation.
- Measurement of thermionic electron work function in the metals.
- Current–voltage characteristic of the diodes. Determination of the Boltzmann constant.
- Stefan–Boltzmann law verification.
- Hall effect.
- Study of photoelectric effect, Planck constant.
- Examination of temperature dependence of resistance of various solids.
- Study of converse piezoelectric effect (stress in response to applied electric field) by the static method.
- Electron paramagnetic resonance (EPR) and Nuclear magnetic resonance (NMR) spectroscopy.
- The study of piezoelectric and elastic properties of polycrystalline ferroelectrics.
- Spontaneous and forced birefringence in TGS crystal.
- Malus Law verification. Pockels and Kerr effect investigation.
- Diffraction of laser beam on 2D grating. Reciprocal lattice.

TEACHING METHODS:

Laboratory exercises - exercises in accordance with the instructions and recommendations of the instructor (may increase the number of measurements to be done and recommend to perform additional analyzes on the basis of measurements).

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
As a result of successfully completing this course, students will be familiar with modern methods of research in the field of solid state physics, optics and physics of atoms and molecules and should understand research limitations.	K2A_W01 K2A_W03 k2A_W04	Intro quiz or test. Parts of the report from measurements (theory, measurement procedure, conclusions)	Lab
Furthermore student should know the safety rules in science experiments. Moreover student has the ability to plan complex physics experiments including different methods of measurement.	K2A_W07 K2A_U02	Supervision of student work at the experimental station, and one of the elements to check the preparation for the measurement (question about the measurement procedure).	Lab
Student is able to handle complex measurement systems using electronic and information technology tools and has the ability to perform accurate measurements and data analysis and make presentation and interpretation of measurement results.	K2A_W5 K2A_U04 K2A_U12	Execution of measurements according to the teacher's guidance, which constitute a modification of the standard exercise. Analysis and presentation of the results of measurements in the report.	Lab

ASSESSMENT CRITERIA:

To pass the laboratory the student should make a reasonable number of exercises in order to get a total of 7.5 points, with the following scores for the exercise:

1,2,3,6 – 1.0 points,

4,7,8,9 – 1.25 points,

5,11,13,14 – 1.5 points,

10,12 – 2.0 points.

The experiments will be conducted in groups of two students. Each student should submit his/her own report. The lab grade consists of two parts: the lab pre-quiz is worth 25% and the lab report is worth 75% of the grade for each lab.

Pre-quiz: Students are expected to prepare for lab by reading the appropriate literature in advance of their lab. The pre-quiz will be taken at the beginning of each lab session and will consist of several questions on material covered in the lab manual.

Lab report: The lab report is a summary of what the student has observed and understood during the lab. Although you will work in twos in the lab, lab reports are to be done individually.

The format is as follows:

<u>Introduction</u>: Briefly give a general overview of the experiment, your expectations (a hypothesis) and the theory behind it. Summarize the main point of doing the lab. Your introduction should be about a 2 pages long.

<u>Results</u>: Present the data in the form of a table or a graph. Usually you will give details of what you observed in the lab. Show any calculations carried out etc. Remember to include units.

<u>Discussion/Conclusion:</u> Discuss in your own words and from your point of view your results.

Example: Looking at your results, tables or graph, can you see any general trend? What is the behaviour of the graph/line? What was the aim of the experiment? Have we achieved anything? If not, how large is the error? Does your result make sense? Can you compare your result to those from the books? What does the book say?

Lab reports are due one week after completion of the last measurement in the experiment.

During the last 3 weeks of the semester the students will have the option to do an extra lab to replace the worst grade and/or to run a make-up lab. At this time, any student who missed a lab, regardless if the absence was excused or unexcused, can make up one lab.

STUDENT WORKLOAD:

- Participation in classes: 15 weeks x 7 hours. = 105 hours.
- Preparation for classes: 5 x 6 = 30 hours.
- Specialized literature-reading: 12 x 5 = 60 hours.
- Analysis of performed exercises and writing reports: 6 x 10 = 60 hours.
- Participating in consultations: 10 hours.

Total: 277 hours, 13 ECTS.

Effort associated with activities that require direct participation of teachers: 115 hours, 6 ECTS.

RECOMMENDED READING:

[1] Each task has its own list of references. The instructor helps the student to choose the most appropriate position, or suggest other items.

OPTIONAL READING:

In Polish:

Poniżej wymienione książki stanowią źródło wiedzy niezbędne w II Pracowni Fizycznej:

[1] R. P. Feynman, R. B. Leighton, M. Sands, *Feynmana wykłady z fizyki*, t. 1-3, Wydawnictwo Naukowe PWN, Warszawa 2001.

[2] David Halliday, Robert Resnick, Jearl Walker. *Podstawy fizyki*, t. 1-5. Wydawnictwo Naukowe PWN, Warszawa 2005/2006.

[3] D. Halliday, R. Resnik, *Fizyka,* PWN, Warszawa 1994.

[4] I. Sawieliew, *Wykłady z fizyki*, PWN, Warszawa 2002.

[5] J. Orear, *Fizyka*, tom 1-2, WNT, Warszawa 2008.

[6] Cz. Bobrowski, *Fizyka - krótki kurs*, WNT, Warszawa 2004.

[7] P.G. Hewitt, *Fizyka wokół nas*, PWN, Warszawa 2008.

Fizyka atomowa i spektroskopia:

[1] Hermann Haken, Hans Christoph Wolf, Atomy i kwanty. Wprowadzenie do współczesnej spektroskopii atomowej, Wydawnictwo Naukowe PWN, Warszawa 1997.

[2] Wolfgang Demtröder, Spektroskopia laserowa, Wydawnictwo Naukowe PWN, Warszawa 1993.

Fizyka ciała stałego:

[1] Neil W. Ashcroft, N. David Termin, *Fizyka ciała stałego*, Państwowe Wydawnictwo Naukowe, Warszawa 1986.

[2] C. Kittel. *Wstęp do fizyki ciała stałego*, Państwowe Wydawnictwo Naukowe, Warszawa 1974.

[3] K. W. Szalimowa, *Fizyka półprzewodników*, Państwowe Wydawnictwo Naukowe, Warszawa 1974.

Optoelektronika i fizyka laserów:

[1] Bernard Ziętek, *Lasery*, Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika, Toruń 2008.

[2] Bernard Ziętek, *Optoelektronika*. Wydawnictwo Uniwersytetu Mikołaja Kopernika, Toruń 2004.

[3] Koichi Shimoda, *Wstęp do fizyki laserów*, Wydawnictwo Naukowe PWN, Warszawa 1993.

Fizyka jądrowa:

[1] Ewa Skrzypczak, Zygmunt Szefliński, *Wstęp do fizyki jądra atomowego i cząstek elementarnych*, Wydawnictwo Naukowe PWN, Warszawa 1995.

[2] Adam Strzałkowski, *Wstęp do fizyki jądra atomowego*, Państwowe Wydawnictwo Naukowe, Warszawa 1979.

[3] Janusz Araminowicz, Krystyna Małuszyńska, Marian Przytuła, *Laboratorium fizyki jądrowej*, Państwowe Wydawnictwo Naukowe, Warszawa 1978.

In English:

For each exercise, the instructor will indicate the literature. However, you may find useful:

General Physics

[1] Richard P. Feynman, Robert B. Leighton and Matthew Sands, *The Feynman Lectures on Physics*, Addison Wesley; 2 edition (August 8, 2005).

[2] David Halliday, Robert Resnick, Jearl Walker, *Fundamentals of Physics*, Wiley; 9 edition (March 16, 2010).

[3] Paul G. Hewitt, *Conceptual Physics*, Addison Wesley; 9th edition (July 2, 2001).

[4] Jay Orear, *Physics*, MacMillan Publishing Company (May 3, 1979).

<u>Atomic Physics and Spectroscopy:</u>

[1] Hermann Haken, Hans Christoph Wolf, W. D. Brewer, *The Physics of Atoms and Quanta*: *Introduction to Experiments and Theory*, pringer; 7th rev. and enlarged ed. 2005 edition (October 19, 2005).

[2] Wolfgang Demtröder, *Laser Spectroscopy*: Vol. 1: *Basic Principles*, Springer; 4th edition (July 29, 2008).

[3] Wolfgang Demtröder, *Laser Spectroscopy*: Vol. 2: *Experimental Techniques*, Springer; 4th edition (September 17, 2008).

<u>Solid State Physics:</u>

[1] Neil W. Ashcroft and N. David Mermin, *Solid State Physics*, Brooks Cole; 1 edition (January 2, 1976).

[2] Charles Kittel, *Introduction to Solid State Physics*, Wiley; 8 edition (November 11, 2004).

[3] Marius Grundmann, *The Physics of Semiconductors: An Introduction Including Nanophysics and Applications*, Springer; 2nd ed. 2010 edition (December 24, 2010).

<u>Optoelectronics and laser physics:</u>

[1] Koichi Shimoda, *Introduction to Laser Physics*, Springer; 2nd edition (September 3, 1986).

[2] Orazio Svelto, *Principles of Lasers*, Springer; 5th ed. 2010 edition (December 28, 2009).

<u>Nuclear physics:</u>

[1] Carlos A. Bertulani, *Nuclear Physics in a Nutshell*, Princeton University Press; 1 edition (April 3, 2007).

[2] Kenneth S. Krane, *Introductory Nuclear Physics*, Wiley; 3 edition (October 22, 1987).

PROGRAM PREPARATION:

Dr Bartosz Brzostowski

THEORETICAL PHYSICS

Course code: **13.2-WF-FizD-FiTeo**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					11
Lecture	45	3	I	Exam	
Class	60	4		Grade	

COURSE AIM:

To familiarize students with the basic concepts of theoretical physics, which are the basis for the development of the whole of modern physics, including a description of the properties of matter, both as a discrete system of points and the continuum, or ensembles made up of large numbers of molecules.

ENTRY REQUIREMENTS:

Knowledge of foundations of physics and mathematics corresponding to educational level undergraduate.

COURSE CONTENTS:

Lectures:

Classical mechanics: *Kinematics and Dynamics of particles and rigid bodies. Galileo transforms. Constrains, D'Alambert's principle, Lagrange equations. Variational principles and conservation laws. Noether theorem. Phase space, Hamilton equations. Invariants of canonical transformations, constants of motion. Relativistic kinematics – Lorentz transformations Minkowski space. Elements of relativistic dynamics. Elements of elastic continuum mechanics.*

Statistical mechanics: *Elements of classical statistical mechanics, Elements of quantum statistical mechanics.*

Classes:

Examples of Newton equations, Kepler problem, two body problem, Euler equation for the rigid body. Lagrange and Hamilton equations, variational principles, phase space, stability of phase trajectories. Elements of relativistic kinematics and dynamics. Elements of classical and quantum statistical mechanics.

TEACHING METHODS:

Conventional lectures and classes

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Skill of theoretical interpretations known experimental physics facts and using mathematical methods and methods of theoretical physics to solve problems and t to describe the processes occurring in nature. Understanding the role of mathematics in physics.	K2A_W03 K2A_W04 K2A_U01	The exam	Conventional lectures
	K2A_W02 K2A_K01 K2A_K05	Credits of exercises	Conventional classes

ASSESSMENT CRITERIA:

LECTURE: The exam

CLASS: Credits of exercises

FINAL SCORE: (60%) exam score + (40%) classes score.

STUDENT WORKLOAD:

- Participation in the lectures: 45 hours
- Participation in the exercises: 60 hours
- Participation in the examination: 2 hours
- Participation in consultation: 5 hours
- Preparation for exam: 45 hours
- Preparation for exercises: 60 hours

Total: 217 hours, 11 ECTS points.

Effort associated with activities that require direct participation of teachers: 112 hours, 5,5 ECTS.

RECOMMENDED READING:

[1] L. D. Landau, E. M. Lifszic, *Teoria pola*, PWN, Warszawa 1976.
[2] W. Garczyński, *Mechanika teoretyczna*, Wyd. Uniwersytetu Wrocławskiego, Wrocław 1978.
[3] I. I. Olchowski, *Mechanika teoretyczna*, PWN, Warszawa 1978.
[4] J. R. Taylor, *Mechanika klasyczna*, PWN, Warszawa 2006.
[5] K. Huang, *Mechanika statystyczna*, PWN, Warszawa 1987.

OPTIONAL READING:

[1] I. Arnold, *Metody matematyczne mechaniki klasycznej*, PWN, Warszawa 1981.
[2] H. Goldstein, *Classical mechanics*.
[3] F. Schutz, *Chaos deterministyczn*y PWN, Warszawa 1995.

PROGRAM PREPARATION:

Dr hab. Krzysztof Urbanowski, prof. UZ

SCIENTIFIC PROGRAMMING IN PYTHON

Course code: **11.3-WF-FizD-PNwJP**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					
Lecture	30	2	I (FK)	Exam	6
Laboratory	30	2		Grade	

COURSE AIM:

The course aim is to introduce the Python as the scientific programming tool. Python is a general purpose, high-level and modern programming language and the capabilities of its standard library as well as the external modules to handle the numerical analysis in physics and related fields will be presented.

ENTRY REQUIREMENTS:

Basic knowledge in programming and object oriented programming.

COURSE CONTENTS:

1. General Python introduction
- language syntex and data types
- flow-control and exceptions
- interactive shell
- scripts
- functions
- modules

2. File I/O operations
- writing to and saving files
- data serialization
- typical I/O operations errors

3. Object Oriented Programming
- classes and objects
- inheritance and polymorphism
- abstractions

4. Introduction to software engineering

- version control systems
- Linux as IDE
- introduction to unit-tests
- software efficiency and profiling

5. Numerical analysis and computer simulations introduction
- the math module
- NuPy's arrays
- random numbers
- basic linear algebra operations in NumPy
- differential equations solvers in NumPy
- data visualisations in the matplotlib module
- introduction to parallel computing with mpi4py

6. Visualization, animations and image processing
- the canvas and graphical primitives
- plots
- animations
- image processing with openCV (computer vision) module

TEACHING METHODS:

Lecture and computer lab, discussions, individual students readings of technical documentation

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student is able to use Python and its standard library to implement a simple software that numerically solves a classical physics problem	K1A_W04 K1A_W09 K1A_U01 K1A_U02 K1A_U07	Activity during laboratories, Projects, Discussions	Laboratory, lecture
Student is able to find out, learn and use the external Python libraries that will help him with the numerical analysis of physical problems	K1A_W04 K1A_W08 K1A_W09 K1A_U01 K1A_U02 K1A_U07	Activity during laboratories, Projects, Discussions	Laboratory, lecture
Student is able to perform graphical data analysis and data visualization using Python and its modules	K1A_W04 K1A_W09 K1A_U01 K1A_U02	Activity during laboratories, Projects, Discussions	Laboratory, lecture
Student is able to solve and present (in spoken and printed form) the outcomes of assigned project .	K1A_U01 K1A_U02 K1A_U05 K1A_U07 K1A_U08 K1A_U09 K1A_K04	Activity during laboratories, Projects, Discussions	Laboratory, lecture

ASSESSMENT CRITERIA:

Lecture: to pass the exam the student will be asked to numerically solve a certain problem of the classical physics or data analysis. The examined knowledge fields and the final exam grade will be evaluated using the following aspects: the problem analysis, presentation of the algorithms used in the problem solution, the presentation of the source code and the validity of the results.

Lab: The final grade will be constructed from the grade related to the report from the project developed during the course (70% of the final grade) and the individual grades obtained during the laboratories (30% of the final grade)

STUDENT WORKLOAD:

- Lecture - 30 h
- Laboratory - 30 h
- Laboratory preparations - 25 h
- Semester project - 25 h
- Examination preparation - 20 h
- Consultations - 3 h
- Examination - 2 h

Total: 135 h, 6 ECTS.

The workload requiring the participation of the teacher: 65 h, 3 ECTS.

RECOMMENDED READING:

[1] Mark Lutz, Learning Python, Fifth Edition, O'Reilly, June 2013.
[2] http://python.org
[3] http://python-ebook.blogspot.com/
[4] http://numpy.scipy.org

PROGRAM PREPARATION:

Dr Sebastian Żurek

MODERN EXPERIMENTAL PHYSICS

Course code: **13.2-WF-FizD-WFDoś**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					2
Lecture	15	1	I (FŚ)	Exam	

COURSE AIM:

Study of the theoretical fundamentals and techniques of methods of the modern experimental physics, in particular, methods and equipment of the structural and spectroscopic investigations.

ENTRY REQUIREMENTS:

The knowledge of fundamentals of the modern physics including thermodynamics and statistical physics, electrodynamics, atomic and nuclear physics, and quantum mechanics in the framework of university courses.

COURSE CONTENTS:

Structure of condensed matter research methods of X-rays diffraction (Debye-Sherrer method, Laue method, rotating crystal method, powder method).

Other methods of structural investigations of the condensed matter (electron diffraction, neutron diffraction, diffraction of helium atoms and hydrogen molecules.

The methods of magnetic resonances spectroscopy including nuclear magnetic resonance (NMR), electron paramagnetic resonance (EPR), ferromagnetic resonance (FMR), and other magnetic resonance methods.

The optical spectroscopy methods (Raman spectroscopy, optical absorption, luminescence).

Other spectroscopic methods for investigations of the condensed matter (X-ray spectroscopy, gamma resonance (or Mössbauer) spectroscopy, beta-ray spectroscopy, alfa-ray spectroscopy, neutron spectroscopy, spectroscopy of other elementary particles.

TEACHING METHODS:

Conventional lecture. Work with books including special monographs and original articles in the scientific journals.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
He has extensive knowledge in the field of physics, including its historical development, both in terms of methodology, the research and the	K2A_W01	Lecture	Exam

relevance of physics to the progress of science, knowledge of the world and of human development.			
He knows the experimental and observational techniques along with their limitations.	K2A_W03	Lecture	Exam
He knows the theoretical basis for the operation of scientific instruments in the field of sciences and scientific disciplines relevant to physics.	K2A_W04	Lecture	Exam
He able to plan and carry out basic experiments or observations about physical problems.	K2A_U02	Lecture	Exam
Understands the need for learning throughout life, is able to inspire and organize the learning process of others.	K2A_K01	Lecture	Exam
He is aware of the social impact of research typical for physics.	K2A_K05	Lecture	Exam

ASSESSMENT CRITERIA:

Oral examination of the full range of material. Passing the exam for a passing grade.

STUDENT WORKLOAD:

- Participation in lectures: 15 h
- Preparing for exam: 20 h
- Consultations: 3 h
- Participation in the exam: 2 h

Total: 40 hours, 2 ECTS.

Effort associated with activities that require direct participation of the teacher – 20 hours, 1 ECTS.

RECOMMENDED READING:

[1] V. Acosta, C. L. Cowan, B.J. Graham, *Podstawy fizyki współczesnej*, PWN, Warszawa 1981.

[2] J. A. Weil, J. A. Bolton. J. E. Wertz, *Electron Spin Resonance. Elementary Theory and Practical Applications*, John Wiley & Sons, New York 1994.

[3] A. Oleś, *Metody doświadczalne fizyki ciała stałego*, WNT, Warszawa 1998.

OPTIONAL READING:

[1] *Encyklopedia fizyki współczesnej*, PWN, Warszawa 1983.

[2] H. Ibach, H. Luth, *Fizyka ciała stałego*, PWN, Warszawa 1996.

[3] Monografie i artykuły oryginalne o metodach doświadczalnych fizyki współczesnej.

PROGRAM PREPARATION:

Dr hab. Bohdan Padlyak, prof. UZ

COMPUTER ASSISTANCE FOR EXPERIMENTS

Course code: **13.2-WF-FizD-KoWsE**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher directing the laboratory exercises**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Laboratory	30	2	I (FŚ)	Grade	

COURSE AIM:

To teach students the use of computer technology necessary for supporting physical experiments.

ENTRY REQUIREMENTS:

Foundations of mathematical statistics and data analysis, the ability to program in any programming languate, the knowledge of mathematical methods of physics

COURSE CONTENTS:

- Introduction to the R programming language
- Data types, the representation of datatypes in R.
- Collecting, storage, transformation and re-use of data.
- Experiment planning, the basic design of experiments, sample size calculation.
- Elements of statistical modelling.
- Linear models, least squares metod, polynomial fit.
- Nonlinear models, the Marquardt-Levenberg method.
- Elements of generalized linear models.
- Elements of signal analysis, Fourier analysis, signal filtering

TEACHING METHODS:

Computer laboratory

LEARNING OUTCOMES:

The student is able to describe the model of data from a specific experiment or the model expected in an experiment (K2A_W03, K2A_U02, K2A_U03, K2A_U04). He or she can transform data and appreciates the collection, storage and re-use of data in a correct way (K2A_U04, K2A_U05). The student can describe the difference between a static and a dynamic model (K2A_W03, K2A_W04). He or she is able to calculate the sample size for a specific experiment (K2A_W03, K2A_U04, K2A_U05). The student is able to build and test linear and nonlinear statistical models of data (K2A_W03, K2A_U04, K2A_U05). The students knows the foundations of spectral analysis and filtering of signals (K2A_W03, K2A_W04, K2A_U05).

LEARNING OUTCOMES VERIFICATION AND ASSESSMENT CRITERIA:

Final test, completion of an assigned project.

STUDENT WORKLOAD:

- Participation in the laboratory: 30h
- Preparation for the laboratory: 20h
- Completion of the assigned project: 25h
- Consultations: 5h

Total: 80 hours, 4 ECTS.
The workload requiring the direct participation of the teacher: 35 hours, 2 ECTS

RECOMMENDED READING:

[1] R. Nowak, *Statystyka dla fizyków*, PWN, Warszawa 2002.

[2] Steven W. Smith, *Cyfrowe przetwarzanie sygnałów DSP. Praktyczny poradnik dla inżynierów i naukowców*, Wydawnictwo BTC, 2007.

OPTIONAL READING:

[1] Optimal Design of Experiments: A Case Study Approach, Peter Goos , Bradley Jones, Wiley

PROGRAM PREPARATION:

Dr hab. Jarosław Piskorski, prof. UZ

MATHEMATICAL METHODS IN PHYSICS

Course code: **11.1-WF-FizD-MeMaF**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	15	1	I (FT)	Exam	
Class	30	2		Grade	

COURSE AIM:

To teach the students basic mathematical tools of differential geometry and tensor analysis necessary to study general relativity.

ENTRY REQUIREMENTS:

Mathematical analysis I and II, and algebraic and geometric methods in physics.

COURSE CONTENTS:

- Elements of multivariable functions analysis: functions from R^n to R^m, continuity, limits, differentiability, Jacobi matrix of transformation, inverse and implicit function theorems

- Elements of differential geometry: Cartesian and curvilinear coordinate systems, in R^n and in a domain of R^n, Curves in Euclidean space, length of curve, Riemannian metrics, natural parametrisation of curve, curvature and torsions, Serret-Frenet formulae, surfaces in R^3, first and second fundamental form of surfaces, mean and Gauss curvatures, hypersurfaces immersed in higher-dimensional flat spaces, notion of differential manifold, coordinates on differential manifold, tangent and cotangent spaces.

- Elements of tensor algebra. Space dual to a vector space, multilinear mapping, transformation laws for tensor and tensor fields, algebraic operations on tensors, differential forms as skew-symmetric tensors, examples of applications of tensors in physics

- Elements of tensor analysis: affine connection, covariant derivative, Christoffel symbols, torsion, Riemannian connection, parallel displacement, equation of parallel displacement, geodesics, curvature tensor, Euclidean coordinate, properties of the Riemann curvature tensor, curvature scalar

TEACHING METHODS:

Conventional lecture with emphasis on contents useful for studies of general relativity

During class students solve exercises illustrating the content of the lecture with examples related to general relativity

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student knows and understands selected issues multivariate analysis, differential geometry and tensor algebra and analysis. He is familiar with the terminology used in these sciences.	K2A_W02	Exam, grade	Lectures, classes
Student can use mathematical methods to describe and model physical phenomena and processes.	K2A_W05	Exam, grade, Discussion	Lectures, classes
Student knows and applies various curvilinear coordinates, determines domain of their definiteness, Student determines natural parametrisation of given curves, calculates curvatures and torsions of curves. Student calculates fundamental forms and curvatures of surfaces.	K2A_W05, K2A_W02, K2A_U05	Exam, grade	Lectures, classes
Student can transform of tensor fields of various types under change of coordinates, make algebraic operations of tensors, calculate Christoffel symbols from metrics and from geodesic equations, determines geodesics. Student calculates curvature tensor and curvature scalar, knows properties of curvature tensor and apply them.	K2A_W05, K2A_W02, K2A_U05	Exam, grade	Lectures, classes
Student can find on their own various teaching materials concerning differential geometry and tensor calculus in Polish and English.	K2A_U09	Exam, grade	Lectures, classes
Student is aware of his knowledge and skills. Student recognise the necessity of permanent training and improvement of his knowledge from application of mathematics to general relativity as well as to contemporary physics.	K2A_K01	Discussion	Classes

ASSESSMENT CRITERIA:

Lecture:

The course credit is obtained by passing a final written exam composed of tasks of varying degrees of difficulty.

Class:

A student is required to obtain at least the lowest passing grade from tests organized during class.

To be admitted to the exam a student must receive a credit for the class

Final grade: average of grades from the class and the exam.

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 1 hour = 15 hours
- Preparation for lectures: 15 hours
- Participation in exam: 2 hours
- Preparation for exam: 18 hours
- Participation in class: 15 weeks x 2 hours = 30 hours
- Preparation for class including preparation for tests: 30 hours
- Attending lecturers' office hours: 10 hours

Total: 120 hours, 6 ECTS points.

Workload connected with lectures and class requiring direct participation of the teacher amounts to 57 hours. This corresponds to 3 ECTS points.

RECOMMENDED READING:

[1] L. M. Sokołowski*, Elementy analizy tenso*rowej, Wydawnictwo Uniwersytetu Warszawskiego, 2010.

[2] M. Spivak, *Analiza na rozmaitościach*, Wydawnictwo Naukowe PWN, Warszawa 2006.

[3] A. Goetz i inni, *Zewnętrzne formy różniczkowe*, WNT, Warszawa 1965.

[4] S. Lovett, *Differential geometry of Manifolds*, A K Peters, Ltd, Natick, Massachusetts 2010.

[5] A. S. Mishchenko, A. Fomenko, *A course of Differential Geometry and Topology*, Mir Publishers Moscow 1988.

[6] B. A. Dubrovin, A.T. Fomenko, S.P. Novikov, *Modern Geometry – Methods and Applications*, Springer 1992.

[7] A. S. Mishchenko, Yu. P. Solovyev,, A. T. Fomenko, *Problems in Differential Geometry and Topology*, Mir Publishers, Moscow 1985.

OPTIONAL READING:

[1] P. M. Gadea, J. Munoz Masque, *Analysis and Algebra on Differentiable Manifolds*, Springer 2009.

[2] T. Banchoff, S. Lovett, *Differential Geometry of Curves and Surfaces*, A K Peters, Ltd, Natick, Massachusetts 2010.

[3] S. Chandrasekhar, *The Mathematical Theory of Black Holes*, Clarendon Press, Oxford 1983.

[4] E. Karaśkiewicz, *Zarys teorii wektorów i tensorów*, Państwowe Wydawnictwo Naukowe, Warszawa 1964.

PROGRAM PREPARATION:

Dr hab. Maria Przybylska, prof. UZ

ASTROPHYSICS I

Course code: **13.7-WF-FizD-Astr1**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	15	1	I (AK)	Exam	
Class	30	2		Grade	

COURSE AIM:

An extension of the knowledge about stellar astrophysics, stellar evolution and binary stars evolution, and the final stages of the stellar evolution.

ENTRY REQUIREMENTS:

Basic knowledge in the field of astrophysics, namely the structure and evolution of stars. Basic knowledge of celestial mechanics.

COURSE CONTENTS:

- The strucrure of stars. Basic laws governing the stellar structure.
- Stellar atmospheres.
- The origin of stellar spectra.
- The influence of physical properties of a star on the shape of spectral lines.
- Evolution of stars of various masses.
- Interstellar clouds, proto-stars, circumstellar disks.
- Properities of main sequence stars of various mass and chemical composition.
- Post-main sequence evolution – giants and supergiants.
- Horizontal branch and asymptotic branch.

TEACHING METHODS:

Classic lecture. Computational exercises during class plus a project method – an extended study of a selected topic from the lecture area of interest.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student can name and explain the basic laws governing teh structure of stars, with the particular focus on the hydrostatic equilibrium. Based on his knowledge of physics and astronomy he can describe the structure of stars of various masses, point out and explain the reasons behind the differences. Student can explain the origin of the stellar spectrum and the influence of various physical properties on the spectral characteristic. Student has extended knowledge of the stellar evolution. He can describe the structure of a star during various stages of the evolution, based on the star's and chemical composition. He can explain the process of stellar formation. He is able to point out and explain the differences in the evolution of stars of different mass	K2A_W01 K2A_W03	Oral exam	lecture
Student has extended knowledge of the stellar evolution. He can describe the structure of a star during various stages of the evolution, based on the star's and chemical composition. He can explain the process of stellar formation. He is able to point out and explain the differences in the evolution of stars of different mass. Using the acquired theoretical knowledge student can solve simple analytical problems concerning the stellar structure and evolution. He can independently study a chosen topic from the field of stellar evolution using the available literature. He is able to present the results of his research in a written form.	K2A_U01 K2A_U03 K2A_U05 K2A_U07 K2A_U11 K2A_U12 K2A_U13 K2A_K01 K2A_K03	Written test, project grade	class

ASSESSMENT CRITERIA:

Lecture: Oral exam, passing condition – positive grade.

Class: written test – solving computational exercises(passing condition – positive grade), and a positive grade from the written research report.

Final grade: a weighted average of the exam grade (70%) and the class grade (30%)

STUDENT WORKLOAD:

- participation in lectures: 15 x 1 = 15 h

- participation in classes: 15 x 2 = 30 h

- preparation for classes: 15 x 2 = 30 h

- homework: 15 x 1 = 15 h

- working on a research project: 15 h

- consultations: 5 h

- exam preparations: 13 h

- participation in the exam: 2 h

TOTAL: 125 h, 6 ECTS.

Workload involving direct teacher participation: 52 h corresponding to 2,5 ECTS.

RECOMMENDED READING:

[1] F. Shu, *Galaktyki, gwiazdy, życie*, Prószyński i S_ka, 2003.
[2] M. Kubiak, *Gwiazdy i materia międzygwiazdowa*, PWN, 1994.

OPTIONAL READING:

[1] J. Mullaney, *Double & Multiple Stars and how to observe them*, Springer 2005.
[2] R. Kippenhann, A. Weigert, *Stellar structure and evolution*, Springer 1996.

PROGRAM PREPARATION:

Dr Wojciech Lewandowski

QUANTUM PHYSICS I

Course code: **13.2-WF-FizD-Fkwa1**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					8
Lecture	30	2	II	Exam	
Class	45	3		Grade	

COURSE AIM:

To teach the student advanced methods of quantum mechanics. To teach approximation methods and give foundations for relativisitc quantum mechanics.

ENTRY REQUIREMENTS

Knowledge of first course of quantum mechanics

COURSE CONTENTS:

- Postulates of quantum mechanics – recollection.
- Approximate methods:
  - Perturbation theory (time independent). Non-degenerate case. Interpretation of Stern-Gerlach effect and Zeeman effect. Degenerate case. Stark effect.
  - Variational principle and variational method. Many-body problem of interacting particles. Mean field approach, self-consistent method.
- Symmetries and conservation laws:
  - Unitary transforamations. General formulation.
  - Translations and conservation of momentum.
  - Rotations and conservation of angular momentum.
  - Translations in time and conservation of energy.
  - Space inversion and parity conservation.
- Second quantization, occupation number representation. Creation and anihilation operators for fermions.
- Occupation number representation. Creation and anihilation operators for bosons.
- Elements of relativistic quantum mechanics:
  - Klein-Gordon equation.
  - Dirac equation.
  - Free electron motion in Dirac theory. Negative energy states.
  - Magnetic moment of electron.
  - Spin.
  - Hydrogen atom in Dirac theory.
- Universal properties of wave packet dynamics in bounded systems.
- Fermi and Bose statistics..

TEACHING METHODS:

Lectures on problems and discussions. Oral practice, in which students solve tasks.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student derives conclusions from particular postulates of quantum mechanics	K2A_W02	Disscussion, tests, exam	Class
Applies several approximate methods	K2A_W02	Disscussion, tests, exam	Class
Is familiar with different representations of physical operator	K2A_W04	Disscussion, tests, exam	Class
Student is able to link symmetries of the quantum system with particular conservation laws	K2A_U06	Disscussion, tests, exam	Class
Is aware of relativistic effects (like spin of fermions) present in quantum systems	K2A_W06	Disscussion, tests, exam	Class

ASSESSMENT CRITERIA:

LECTURE: A course credit for the lectures is obtained by taking a final exam composed of tasks of varying degrees of difficulty.

CLASS: During the classes the preparation of the students will be checked as well as their understanding of the lecture content at the time of the lectures.

To obtain a course credit for the exercises 50% of the maximum number of points will be required, which can be achieved through two cumulative tests. A student who achieves at least 10% of the maximum points and who does not exceed the class absence limit has the right to a resit test of the entire material before the examination date. The result of the exam is also affected by class participation and preparation for the class.

Entrance to the exam requires prior accreditation of the course exercises.

STUDENT WORKLOAD:

Contact hours:

- Lectures: 30 hours
- Exercises: 45 hours
- Consultation: 10 hours
- Exam; 2 hours

Total: 87 hours, 4 ECTS

Individual workload of student:

- Preparation for lectures and exam: 30 hours
- Preparation for exercises and tests: 45 hours

Total: 162 hours, 8 ECTS.

RECOMMENDED READING:

[1] P. Rozmej, *Lecture Notes,* pdf file, delivered to students.

[2] St. Szpikowski, *Elementy mechaniki kwantowe*j, Wyd. UMCS, 1999.

OPTIONAL READING:

[1] I. Białynicki-Birula, M. Cieplak, J. Kamiński, *Theory of quanta,* PWN, Warszawa 2001.

[2] A. L. Schiff, *Quantum mechanics,* PWN, Warszawa 1987.

PROGRAM PREPARATION:

Prof. dr hab. Piotr Rozmej

INTRODUCTION TO ATOMIC AND MOLECULAR PHYSICS

Course code: **13.2-WF-FizD-WdFAC**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					7
Lecture	30	2	II	Exam	
Class	30	2		Grade	

COURSE AIM:

The aim of the course is to teach the students methods and applications of quantum mechanics in description of matter-matter interactions; at the scale of one or a few atoms and energy scales around several electron volts. In particular we present the approximated methods, method of self consistent field and variational methods in atomic physics.

ENTRY REQUIREMENTS:

Quantum mechanics and Classical electrodynamics courses.

COURSE CONTENTS:

LECTURE: One-electron atoms. Eigenvalues, quantum numbers, degeneracy, Zeeman effect, spin. The orbit-spin interaction. Identical particles, Pauli rule Multielectron atoms. Hartree-Fock theory, the self consistent field. The periodic table. Optical excitations, atomic spectra. Molecules, Born-Oppenheimer theory, LCAO MO theory. Molecular spectra, rotation, vibration-rotation and electron spectra. Raman effect.

CLASS: A hydrogen atom, quantum numbers, atom orbitals, spin. Multielectron atoms, the periodic table. The orbit-spin interaction, atomic spectra. Molecules spectra.

TEACHING METHODS:

Conventional lectures, calculate class.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Skill of theoretical interpretation of experimental facts	K2A_W03	Exam, controlling during calculate class	class
Application of mathematical methods in	K2A_W02	Exam, controlling during	class

solving physical problems		calculate class	

The basic aim of the course is a presentation of approximated methods in description od atoms and molecules. The course is devoted to increasing the students working knowledge of physics principles and problem solving skills.

ASSESSMENT CRITERIA:

<u>LECTURE</u>: The exam

<u>CLASS</u>: Credits of exercises

STUDENT WORKLOAD:

- Participation in the lectures: 30 hours

- Participation in the exercises: 30 hours

- Participation in the examination: 2 hours

- Participation in consultation: 5 hours

- Preparation for exam: 30 hours

- Preparation for exercises: 40 hours

Total: 137 hours, 7 ECTS points.

Effort associated with activities that require direct participation of teachers: 67 hours, 3,5 ECTS.

RECOMMENDED READING:

[1] W. Kołos, J. Sadlej, *Atom i cząsteczka*, WNT, Warszawa 2007.

[2] J. Ginter, *Wstęp do fizyki atomu, cząsteczki i ciała stałego*, PWN, Warszawa 1986.

[3] I. Białynicki-Birula, M. Cieplak, J. Kamiński, *Teoria kwantów*, PWN, Warszawa 1991.

[4] W. Kołos, *Chemia kwantowa*, PWN, Warszawa 1980.

[5] L. Schiff, *Mechanika kwantowa*, PWN, Warszawa 1977.

OPTIONAL READING: -

PROGRAM PREPARATION:

Dr hab. Anatol Nowicki, prof. UZ

APPLICATIONS OF COMPUTER SIMULATIONS

Course code: **11.3-WF-FizD-SKwZa**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	30	2	II (FK)	Exam	
Laboratory	30	2		Grade	

COURSE AIM:

The aim of the course is to gain a knowledge of computer simulation methods, their applications, strong and weak sides. Students should acquire skills in implementation of this knowledge by designing the proper algorithms and then interpreting the results of computer simulations.

ENTRY REQUIREMENTS:

Object oriented programming in Java or Python or C++, introduction to computer simulations, basics of MD and MC algorithms and techniques.

COURSE CONTENTS:

- Random walk – lattice and off-lattice, lattice gas model
- Percolation
- MC simulations of spin system with interactions
- Queue systems
- Computer simulations of polymers
- Basics of Molecular Dynamic – revision
- System with two atom interactions
- Molecular mechanics and force field
- NVE, NPT, NVT ensemble – MD simulations

TEACHING METHODS:

Lectures and laboratory exercises, discussions, independent work with a specialized scientific literature in Polish and English, and work with the technical documentation and search for information on the Internet.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Students expand their ability to acquire knowledge in different ways using a variety of sources.	K2A_U10	activity during laboratories, project, discussion, exam	laboratory, lecture
They have practical knowledge on modeling using pseudo-random number generator and deterministic methods.	K2A_W02	activity during laboratories, project, discussion, exam	laboratory, lecture
Students have an extended knowledge of classical physics of interacting systems. They know numerical error analysis, numerical methods of solving differential equations, they can use molecular dynamics methods, methods of Monte Carlo.	K2A_W01 K2A_W05	activity during laboratories, project, discussion, exam	laboratory, lecture
They have skills in data analysis, they posses knowledge which is acquired during studies of the scientific literature.	K2A_U05 K2A_U03 K2A_U10	activity during laboratories, project, discussion, exam	laboratory, lecture
Characteristic feature is the expanding awareness of the need to update the technical knowledge on the available techniques and simulation resultss well as awareness of the impact of research on the development of computer technology, including in particular nanotechnology.	K2A_K01 K2A_K05	activity during laboratories, project, discussion, exam	laboratory, lecture

ASSESSMENT CRITERIA:

- **Lecture**: positive evaluation of the practical exam.
- **Laboratory**: evaluation of laboratories of 30%, the assessment of the project 70%.
- Before taking the examination the student needs to obtain passing grade in the laboratory exercises.
- **The final grade:** the arithmetic average of the examination grade and laboratory exercises grade.

STUDENT WORKLOAD:

- Participation in lectures: 30 hours
- Participation in exercises: 30 hours
- Preparation for the exercises: 20 hours
- Project preparation: 30 hours
- Consulting for the lectures and exercises: 5 hours
- Preparation for the completion of the lecture: 10 hours
- Exam: 2 hours

TOTAL: 127 hours, 6 ECTS.

Contact hours: 67 hours, 3 ECTS.

RECOMMENDED READING:

[1] D. Frenkel, B. Smit, *Understanding Molecular Simulation. From Algorithms to Applications,* Academic Press 2002.

[2] M. P. Allen, D. J. Tildesley, *Computer Simulation of Liquids*, Oxford University Press 1990.

[3] D. P. Landau, K. Binder, *A guide to Monte Carlo Simulations in Statistical Physics,* Cambridge

University Press, 2005.
[4] K. Binder, D. W. Heerman, *Monte Carlo Smulation in Statistical Physics*, Springer 2010. (5th ed).

OPTIONAL READING: -

PROGRAM PREPARATION:

Dr Marcin Kośmider

UNIX OS PROGRAMMING

Course code: **11.3-WF-FizD-UNIX**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher directing the laboratory exercises**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					3
Laboratory	30	2	II (FK)	Grade	

COURSE AIM:

To teach students how to use advanced programmer tools available in *UNIX operating system with the emphasis on the tools often used in supercomputing-clusters

ENTRY REQUIREMENTS:

Ability to program in one of the following programming languages: C/C++/Java/Python, ability to use the *UNIX based systems in the user level

COURSE CONTENTS:

- GNU toolchain: a programmer toolset provided with *UNIX systems by the GNU project (gcc, automake, autoconf, binutils i inne)
- GNU Emacs as IDE
- Shared and static libraries
- Low-level streaming (vector) instructions (SSE programming)
- Parallel programming with OpenMPI
- OpenMPI interfaces (bindings) to high-level scripting languages: examples in Python programming language

TEACHING METHODS:

Computer lab, discussions, individual students readings of technical documentation

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Ability to write efficient programs using GNU toolchain.	K2A_W05 K2A_U05 K2A_U06	Working with computer, oral answer, written answer, current control	laboratory
Basic knowledge in high-performance computing with SIMD streaming	K2A_U05 K2A_U06	Working with computer, oral answer, written	laboratory

Instructions.		answer, current control	
Parallel programing with MPI interface.	K2A_U05 K2A_U06	Working with computer, oral answer, written answer, current control	laboratory

ASSESSMENT CRITERIA:

Two laboratory projects implemented during the course are marked positively:

- the Ising model Monte-Carlo simulation implemented in parallel technique with the scientific rapport created in LaTex system (50% of final grade),
- development of helping-tools enhancing the scientific work in supercomputing-cluster: running scripts in queue systems, automated e-mail reporting on broken or finished calculation tasks, programs re-running , etc. (50% of final grade).

STUDENT WORKLOAD:

- Laboratory: 30 h
- Laboratory preparation: 20 h
- Individual projects workload: 20 h
- Consultations: 5 h

Total: 75 h, 3 ETCS.

The workload requiring the participation of the teacher: 35 h, 1,5 ECTS.

RECOMMENDED READING:

[1] Peteresn Arbenz, *Introduction to Parallel Computing*, Oxford University Press, 2004.

[2] Intel(R) 64 and IA-32 Architectures Optimization Reference Manual (http://developer.intel.com/assets/pdf/manual/248966.pdf)

OPTIONAL READING:

[1] Papers on MPI applications: http://www.open-mpi.org/papers/

[2] GNU Emacs Manual (http://www.gnu.org/software/emacs/manual/emacs.pdf)

PROGRAM PREPARATION:

Dr Sebastian Żurek

SYMBOLIC PROGRAMMING IN PHYSICAL PROCESSES SIMULATIONS

Course code: **11.3-WF-FizD-PSSPF**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher directing the laboratory exercises**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					3
Laboratory	30	2	II (FK)	Grade	

COURSE AIM:

Students can use a Computer Algebra Systems (Mathematica, Sage, Maxima as examples) in symbolic problem solving in physics and verification of analytical calculations.

ENTRY REQUIREMENTS:

Knowledge of calculus and linear algebra and the basis of classical mechanics, classical electrodynamics and quantum mechanics. Programming in C or Fortran.

COURSE CONTENTS:

1) Introduction to computer algebra (wxMaxima, Mathematica):
   - Sessions, evaluation of expressions, environment variables,
   - Differentiation and integration,
   - Systems of linear equations,
   - 2D and 3D plots and data visualization,
   - Differential equations.
2) Classical Mechanics:
   - Harmonic oscillator,
   - Coupled harmonic oscillators,
   - Two-body problem.
3) Electrodynamics:
   - Discrete distribution of charges,
   - Poisson equation,
   - Charged particle in an electromagnetic field.
4) Quantum Mechanics:
   - Potential barrier,
   - Potential well,
   - Harmonic oscillator,
   - Hydrogen atom.

TEACHING METHODS:

Laboratory classes in the computer lab. Working in groups. Joint solving of more complex or laborious examples.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student can present a problem in terms of the physical laws and principles to propose its mathematical model	K2A_W02 K2A_U03	completion of all exercises	laboratory classes in the computer lab
Student can use the CAS system to analyze the experimental data and for graphical representations of data; is able to analyze the results, present and discuss conclusions	K2A_W05 K2A_U03 K2A_U04 K2A_U05		
Student can use symbolic and numerical calculations in the CAS to solve physical problems; is able to analyze the obtained solution and perform its verification by comparison with known analytical solution (if it exists)	K2A_W02 K2A_W05 K2A_U04 K2A_U06		

ASSESSMENT CRITERIA:

The condition of positive assessment is the accomplishment of all programming exercises.

Final assessment: the weighted average of the final test (50%) and programming exercises (50%).

STUDENT WORKLOAD:

- Laboratory classes: 30 h
- Self-learning on homework tasks: 30 h
- Consultations: 2 h

Total: 62 h, 3 ECTS.

Workload directly involving teacher: 32 h, 1,5 ECTS.

RECOMMENDED READING:

[1] L. D. Landau, E. M. Lifszyc „Mechanics”, Vol. 1, (3rd ed.), Butterworth–Heinemann 1976.

[2] D. J. Griffiths, „Introduction to Electrodynamics”, (3rd ed.), Addison Wesley 1999.

[3] L. Piela, „Ideas of Quantum Chemistry”, (1st ed.), Elsevier 2006.

[4] S. Wolfram, *The mathematica book*, 5-th ed., Wolfram Media 2003.

[5] http://maxima.sourceforge.net/docs/tutorial/en/gaertner-tutorial-revision/Contents.htm

OPTIONAL READING: -

PROGRAM PREPARATION:

Dr Tomasz Masłowski

SCRIPTING LANGUAGES IN DATA ANALYSIS

Course code: **11.3-WF-FizD-JSwAD**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher directing the laboratory exercises**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					3
Laboratory	30	2	II (FK)	Grade	

COURSE AIM:

The primary language is the Python programming language and by using it students should acquire the ability to analyze data on examples of specific tasks. Students should familiarize themselves with the available Python libraries, data analysis methods and they should be able to use them in practical tasks.

ENTRY REQUIREMENTS:

It is assumed elementary programming skills in any programming language, and knowledge of basic mathematical methods of data analysis.

COURSE CONTENTS:

- Introduction to programming in Python.
- Python libraries: NumPy, pandas, matplotlib, SciPy.
- Basics of NumPy (data processing using arrays, mathematical and statistical methods, read and write data to disk in binary or text).
- Pandas basics: read and write data to disk in various formats (CSV, Microsoft Excel), multi-dimensional data.
- Basics of Matplotlib: data plots, visualization.
- Time series (methods of analysis).

TEACHING METHODS:

Laboratory exercises, individual work and group work, exchange of ideas, work with documentation, self-knowledge acquisition, project.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student knows the information technology used to solve common problems in the field of physical sciences and understands their limitations.	K2A_W05	Working with computer, oral answer, written answer, current control	laboratory

Student understands the complexity of the issues relating to access to the data, the appropriate analysis of data and data storage. Based on empirical data, student can build simple mathematical models adequate to physical problems.	K2A_U03	Working with computer, oral answer, written answer, current control	laboratory
Student is able to work effectively in a group assuming different roles according to the situation.	K2A_K03	Working with computer, oral answer, written answer, current control	laboratory

ASSESSMENT CRITERIA:

Score: average grades achieved during the activity and short tests advances in science (50% of the final mark) and the assessment of the semester project (50% of the final mark). To pass the semester project is its preparation and commitment within the prescribed period of the project report as well as its presentation.

STUDENT WORKLOAD:

- Participation in laboratory: 30 h
- Preparation for the laboratory: 20 h
- Project preparation: 20 h
- Preparation for the completion of the lecture: 15 h
- Consulting: 3 h

Total: 73 h, 3 ECTS.

Contact hours: 33 h, 1,5 ECTS.

RECOMMENDED READING:

[1] Allen Downey, Think Python. How to Think Like a Computer Scientist, 2013. Green Tea Press, Needham, Massachusetts.

[2] Wes McKinney, Python for Data Analysis,O'Reilly Media Inc. (2013)

OPTIONAL READING:

[1] Internet

PROGRAM PREPARATION:

Dr Krzysztof Krzeszowski

COMPUTER SIMULATIONS

Course code: **13.2-WF-FizD-FŚ-SyKom**
13.2-WF-FizD-FT-SyKom

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					7
Lecture	30	2	II (FT, FŚ)	Exam	
Laboratory	30	2		Grade	

COURSE AIM:

The aim of the course is to gain basic knowledge of computer simulation methods and the ability to choose the appropriate simulation model to the considered problem. Students should acquire skills in implementation of this knowledge by designing the proper algorithms and then interpreting the results of computer simulations.

ENTRY REQUIREMENTS:

Ability to use some programming language.

COURSE CONTENTS:

- Representation of numbers, excess and underflow errors, truncation error (finite difference method), the stability of numerical algorithms.
- Algorithms for solving the equations of motion: Euler, Verlet, velocity Verlet, numerical solution of the harmonic oscillator.
- Monte Carlo algorithms (random number generators, random variables with different probability distributions, Metropolis algorithm, stochastic equations).
- Selected examples of applications (simulation of phase transitions, relaxation of the electric dipole)

TEACHING METHODS:

Lectures and laboratory exercises, discussions, independent work with a specialized scientific literature in Polish and English, and work with the technical documentation and search for information on the Internet.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Students expand their ability to acquire knowledge in different ways using a variety of sources.	K2A_U10	discussion	exercise
They have practical knowledge on modeling using pseudo-random number generator and deterministic methods.	K2A_W02 K2A_W02	test exam	exercise lecture
Students have an extended knowledge of classical physics of interacting systems.	K2A_W01	discussion	exercise
Students know numerical error analysis, numerical methods of solving differential equations, they can use molecular dynamics methods, methods of Monte Carlo.	K2A_W05	discussion test exam	exercise exercise lecture
They have skills in data analysis, they posses knowledge which is acquired during studies of the scientific literature.	K2A_U03 K2A_U05 K2A_U10	discussion test exam	exercise exercise lecture
Characteristic feature is the expanding awareness of the need to update the technical knowledge on the available techniques and simulation results as well as awareness of the impact of research on the development of computer technology, including in particular nanotechnology.	K2A_K01 K2A_K05	discussion test exam	exercise exercise lecture

ASSESSMENT CRITERIA:

Lecture: positive evaluation of the test.
Laboratory: positive evaluation of the tests, the execution of the project.
The final evaluation of the laboratory: evaluation of tests of 60%, the assessment of the project 40%.
Before taking the exam the student must be credited with the exercises.
Final grade: arithmetic mean of the completion of the lecture and in excersises.

STUDENT WORKLOAD:

- Participation in lectures: 30 hours
- Participation in exercises: 30 hours
- Preparation for the exercises: 30 hours
- Project preparation: 20 hours
- Consulting for the lecturees and exercises: 5 hours
- Preparation for the completion of the lecture: 20 hours
- Exam: 2 hours

TOTAL: 137 hours, 7 ECTS

Contact hours: 67 hours, 3.5 ECTS

RECOMMENDED READING:

[1] J. C. Berendsen and W. F. Van Gunsteren, *Practical Algorithms for Dynamic Simulations in Molecular dynamics simulations of statistical mechanical systems*, Proceedings of the Enrico Fermi Summer School, p. 43 - 45, Soc. Italinana de Fisica, Bologna 1985.

[2] Stephen Wolfram, *Statistical mechanics of cellular automata*, Rev. Mod. Phys. 55, 601 - 644 (1983).

OPTIONAL READING:

[1] William H. Press, Saul A. Teukolsky, William T. Vetterling, Brian P. Flannery, *Numerical recipes, The art of scientific computing*, third edition 2007.

PROGRAM PREPARATION:

Dr hab. Mirosław Dudek, prof. UZ

COMPUTATIONAL METHODS IN ENVIRONMENTAL PHYSICS

Course code: **13.2-WF-FizD-MOwFŚ**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher directing the classes**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					3
Class	30	2	II (FŚ)	Grade	

COURSE AIM:

Students can apply the appropriate laws of physics to describe the environmental issues, can use spreadsheets for presentations and analysis of empirical data, have the ability to interpolate and extrapolate the empirical data.

ENTRY REQUIREMENTS:

Knowledge of linear algebra and mathematical analysis, basic knowledge of MS Office or OpenOffice, the ability to program in C or another language. Fundamentals of Physics.

COURSE CONTENTS:

The methods of presenting of measurement data, typical dependences used to represent physical laws (linear, quadratic, inverse proportionality, inverse quadratic, exponential, periodic).

Spreadsheet (eg. MS Excel) as a tool for mathematical calculations.

Using the defined functions and creation of own ones. Generation of charts and histograms.

Interpolation and extrapolation of data. The use of a polynomial interpolation to calculate the temperature dependance of the surface tention of water. The use of Richardson's extrapolation to determine the coefficient of viscosity of the water, comparing the received values with the table data.

Threats to the environment – the model of a failure and the probability of its occurrence, Rasmussen's method for genealogy of accident. Discussion of the frequency of accidents on the example of nuclear reactor accidents, fires and earthquakes.

The laws of physics in the environment on the example of water flow in the soil. The water flow under the influence of gradient of capillary and hydrostatic pressures (Poiseuille and Darcy's law).

Conservation laws and equations of fluid dynamics (Bernoulli's principle, Navier-Stokes equation), dimensional analysis and the similarity numbers (Strouhal, Euler, Freude'a, Reynolds and Richardson numbers).

The proliferations of contamination. Diffusion equation, advection. The spread of gaseous pollutants in the atmosphere.

TEACHING METHODS:

Laboratory exercises in the computer lab. Working in groups, common solving of more complex examples.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student is able to explain the flow of water based on Poiseuille and Darcy's laws, understanding their approximate character and understands the importance of that description to the society	K2A_W01 K2A_W02 K2A_U01 K2A_K02	tests	classes, laboratory exercises in the computer lab
Student knows what is dimensional analysis and the similarity numbers	K2A_W02 K2A_U07		
Student is able to define and describe theoretically the risk to the environment as a result of possible human factors and the effects of natural elements using the method of Rasmussen	K2A_W02 K2A_W05 K2A_U03		
Student understands the effects of natural disasters, accidents and environmental factors	K2A_K05		
Student is able with the aid of the spreadsheet to interpret data and using methods of interpolation and extrapolation provide additional results	K2A_U04 K2A_U05		
Student after the preparation of the final project is able to assess the degree of his or her knowledge and complete it using the available literature and the internet	K2A_U09 K2A_U10		

ASSESSMENT CRITERIA:

Classes: passing two tests, and performing the final project.

Final evaluation of laboratory exercises: arithmetic mean of the tests and the project.

STUDENT WORKLOAD:

- Participation in the exercises: 30 hours.
- Preparing for exercises: 20 hours.
- Preparation of the final project: 10 hours.
- Consultation: 3 hours.

TOTAL: 63 hours, 3 ECTS.

Workload directly involving teacher: 33 hours, 1.5 ECTS.

RECOMMENDED READING:

[1] Maria Przybylska, *Fizyka środowiska – zanieczyszczenie środowiska naturalnego*, skrypt, Zielona Góra 2012.

[2] Henryk Szydłowski, *Pracownia fizyczna*, Wydawnictwo Naukowe PWN, Warszawa 1994.

[3] Wojciech Szymański, *Elementy nauki o promieniowaniu jądrowym dla kierunków ochrony środowiska*, Wydawnictwo Uniwersytetu M. Kopernika, Toruń 1999.

[4] Stanisław Przestalski, *Elementy fizyki, biofizyki i agrofizyki,* Wydawnictwo Uniwersytetu Wrocławskiego, Wrocław 2001.

[5] Jerzy Lech Kacperski, *I Pracownia fizyczna*, Wydawnictwo Uniwersytetu Łódzkiego, Łódź 1998.

[6] David M. Bourg, *Excel w nauce i technice - Receptury*, Helion, Gliwice 2006.

[7] Zbigniew Smogur, *Excel w zastosowaniach inżynieryjnych*, Helion, Gliwice 2008.

OPTIONAL READING:

[1] Maciej Matyka, *Symulacje komputerowe w fizyce*, Helion, Gliwice 2002.

[2] Edward Mulas, *Przykłady symulacji komputerowej w fizyce*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2006.

PROGRAM PREPARATION:

Dr Tomasz Masłowski

ENVIRONMENTAL CHEMISTRY

Course code: **13.3-WF-FizD-CheŚr**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **dr hab. Jacek J. Kozioł, prof. UZ**
Name of lecturer: **dr hab. Jacek J. Kozioł, prof. UZ**
mgr Bartłomiej Zapotoczny

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					5
Lecture	30	2	II	Exam	
Laboratory	15	1		Gradr	

COURSE AIM:

Transfer of knowledge on the structure of matter with a particular focus the elements and compounds, and their role in nature, including in living organisms

ENTRY REQUIREMENTS:

Knowledge of chemistry at the high school level

COURSE CONTENTS:

Lecture: Basic concepts and laws of chemistry. The periodic table of elements. Structure of the molecules. Chemical bonding.. The polarity of the molecules. Acids, bases, salts, amphoteric compounds. Properties of solutions: strong and weak electrolytes, electrolytic dissociation in the water and the concept of pH, hydrolysis of salts. Buffer solutions. Solubility. Types of chemical reactions. Elements of Organic Chemistry: basic types of organic methods for their preparation and their physical and chemical properties.
Exercises: Solutions: preparing standard solutions, precipitation, purification by dissolving the substance, crystallization, extraction. Properties of actual and colloidal solutions and appropriate: synthesis, degradation. Types of chemical compounds: methods of preparation, properties. Properties of electrolyte solutions. pH indicators. Redox reactions. Selected methods of quantitative analysis

TEACHING METHODS:

by providing (lecture in the form of a multimedia presentation)

- practical (lab exercises using basic chemical laboratory equipment)

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Has extensive knowledge of chemistry, including its historical development, both in terms of methodology, the research and the relevance of chemistry to the progress of science, knowledge of the world and of human development.	K2A_W01	Final examination for which the student is allowed under the prior credit exercises, carried out in writing. The exam lasts 60 minutes contains 5 issues requiring discussion	Lecture
He knows the experimental and observational techniques along with their limitations.	K2A_W03		
Able to plan and carry out basic experiments or observations on the physico-chemical aspects.	K2A_U02		
Able to critically assess the results of experiments, observations and theoretical considerations, including those discussed measurement errors.	K2A_U04		
Can understand the problems of knowledge areas common to physics and science related to it as chemistry or biology.	K2A_U07		
Understands the need for learning throughout life, can inspire and organize the learning process of others people.	K2A_K01		
Able to work effectively in a group, assuming different roles according to the situation.	K2A_K03		
Knows the experimental and observational techniques and their limitations.	K2A_W03	Present the results of experiments in the form of a report appearing in the daily laboratory. Verification of knowledge in writing - test.	Laboratory exercises
Knows the rules and safety sufficiently to work independently in the profession of physics.	K2A_W07		
Able to plan and carry out basic experiments or observations on the physico-chemical issues.	K2A_U02		
Able to critically evaluate the results of experiments, observations and theoretical considerations, including the measurement errors discussed.	K2A_U04		
Can understand the problems of knowledge areas common to physics and science related to it such as chemistry or biology.	K2A_U07		

ASSESSMENT CRITERIA:

Lecture. Final examination for which the student is allowed under the prior credit exercises, carried out in writing. The exam lasts 60 minutes contains 5 issues requiring discussion. To pass the assessment, it is necessary to obtain sufficient 60 points. (60%) of 100 points. possible to get.

Exercise. Implementation of the program exercises course (attendance is mandatory in cases of absence, the student should fill the gaps in the time agreed with the teacher). Present the results of experiments in the form of a report appearing in the daily laboratory. Verification of knowledge in writing - test. Final evaluation is the arithmetic mean of the partial.

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 2 hrs. = 30 hours
- Participation in the exercises: 15 weeks x 1 hour = 15 hours
- Participation in consultations: 4 hours
- To prepare for the written test: 25 hours
- Participation in the exam: 2 hour

- Preparation for laboratory classes: 8 hours
- Keeping a journal lab: 6 hours
- Individual preparation for the written tests: 10 hours

TOTAL: 100 hours, 5 ECTS.

RECOMMENDED READING:

[1] P. A. Cox, *Chemia nieorganiczna*, Wydawnictwo Naukowe PWN, Warszawa 2004.

[2] L. Jones, P. Atkins, *Chemia ogólna*, Wydawnictwo Naukowe PWN, Warszawa 2004.

[3] G. Patrick, *Chemia organiczna*, Wydawnictwo Naukowe PWN, Warszawa 2004.

[4] A. G. Whittaker, A. R. Mount, M. R. Heal, *Chemia fizyczna*, Wydawnictwo Naukowe PWN, Warszawa 2004.

OPTIONAL READING:

[1] A. Bielański, *Chemia ogólna i nieorganiczna,* Wyd. 8, PWN, Warszawa 1982.

[2] W. Kołos, J. Sadlej, *Atom i cząsteczka*, WNT, Warszawa 1998.

PROGRAM PREPARATION:

Dr hab. Jacek J. Kozioł, prof. UZ

PACKAGES FOR SYMBOLIC COMPUTATIONS

Course code: **11.3-WF-FizD-PdObS**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher directing the laboratory exercises**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					3
Laboratory	30	2	II (FT)	Grade	

COURSE AIM:

Student's abillity to use Packages for Symbolic Computations and as a support in solving problems in Physics and Mathematics and for Data Visualization.

ENTRY REQUIREMENTS:

Knowledge of Linear Algebra and Mathematical Analysis (Ordinary and Partial Differantial Equations). Programming Skills in C or other language.

COURSE CONTENTS:

Functions and Structures in "Mathematica".

Numerical Calculations, Variables and Formatting (*N, Round, Random*).

Logical Variables and Operators.

Lists, Vectors and Matrices. (*Range, List, Table, Array, Length*).

Operations on Strings (*Union, Join, StringJoin*).

Algebraic Manipulation (*Cancel, Together, Apart, Expand, Factor, Collect, Simplify*).

Differentiation and Integration (*D, Integrate, Nintegrate*).

Solving of Algebraic and Differential Equations (*Solve, FindRoot, DSolve*).

Generating of Two- and Three-Dimensional Graphics (*Plot, Plot3D, ListPlot*).

Visualization and Data Manipulation (*Fit, Histogram*).

Special Functions.

The Use of Packages.

Other programms for symbolic computation (*Maple, Maxima*).

TEACHING METHODS:

Laboratory classes. Working in groups, joint solving of more complicated or laborious examples.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student knows necessary *Mathematica's* functions (operations on matrices, on text variables, algebraical operations, solving of algebraical and differential equations, symbolical and numerical integration, etc.) which helps in solving and visualization of certain problems in Classical Mechanics, Classical Electrodynamics and Quantum Mechanics; knows *Mathematica's* formats *.nb*, *.m* i *.mx*.	K2A_W05	Accomplishment of programming exercises	laboratory classes
Student can analyze empirical data using *Mathematica's* functions (*Fit, Histogram, BarChart*); can make use of graphical functions and their options to emphasize desired informations on a plot (*PlotStyle, Mash, Filling)*; can solve basic differential equations of Classical Electrodynamics and Quantum Mechanics and present them graphically.	K2A_U03		
Student can make use of built-in as well as external *Mathematica's* packages (.m format) to solve simple problems in Physics; can create their own packages.	K2A_U06		

ASSESSMENT CRITERIA:

The condition of positive assessment is the accomplishment of all programming exercises.

STUDENT WORKLOAD:

- Laboratory classes: 30 h
- Self-learning on homework tasks: 30 h
- Consultations: 2 h

Total: 62 hours, 3 ECTS.

Workload directly involving teacher: 32 hours, 1,5 ECTS.

RECOMMENDED READING:

[1] S. Wolfram, *The mathematica book*, 5-th ed., Wolfram Media 2003.

[2] E. Don, *Mathematica*, McGraw-Hill, 2001.

[3] R. Grzymkowski, A. Kapusta, D. Słota, *Mathematica narzędzie inżyniera*, Wyd. Pracowni Komputerowej J. Skalmierskiego, Gliwice 1994.

OPTIONAL READING: -

PROGRAM PREPARATION:

Dr Tomasz Masłowski

STATISTICAL PHYSICS

Course code: **13.2-WF-FizD-FiSta**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					5
Lecture	15	1	II (FT)	Exam	
Class	30	2		Grade	

COURSE AIM:

The aim of the course is to present the methods of modern statistical physics in ergodic theory, critical phenomena, nonlinear chemical physics, physics of quantum systems, transport theory

ENTRY REQUIREMENTS:

It is assumed knowledge of thermodynamics, general physics and mathematical methods.

COURSE CONTENTS:

1) Equilibrium statistical mechanics
   - Methods of thermodynamics (the method of thermodynamic potentials, equation of state)
   - Ergodic theory
   - Statistical ensembles (microcanonical ensemble, the canonical ensemble, grand canonical ensemble)
   - Theory of solid state (classical theory of solids, Einstein theory of solids, Debye theory of solids)
   - Ideal gas (classical and quantum gases, Maxwell-Boltzmann gas, Bose-Einstein gas, Fermi-Dirac gas)
   - Order-disorder phase transitions (van der Waals equation, Ising model, Lee-Yang theory of phase transitions)
   - Critical phenomena (scaling, critical exponents, renormalisation group transform)
2) Transport theory (kinetic theory, Boltzmann equation)
3) Fluctuation-dissipation theorem

Exercises to the lecture concern specific topics, increase calculation skills. Emphasized are the equation of state, the equilibrium statistical mechanics soluble models, classical and quantum fluids.

TEACHING METHODS:

In addition to traditional lectures multimedia resources are used, the internet etc. In exercises students gain skills while calculating thermodynamic features of the physical systems, they participate in the discussion.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Students are familiar with the basic statistical models that can be used to describe the phenomena of equilibrium and non-equilibrium physics. They are able to distinguish between classical and quantum description. They can explain physical phenomena	K2A_W01 K2A_W04	test discussion exam	exercise excersise lecture
They can present the basic theorems and physical laws with their justification	K2A_U01	test discussion exam	exercise excersise lecture
They have skills in application of the statistical physics in the overlapping fields of science at he same time fulfilling social requirements	K2A_U07 K2A_K05	test discussion exam	exercise excersise lecture

ASSESSMENT CRITERIA:

The lecture ends with the completion of the evaluation. Examination is a written test of theoretical knowledge and practical computational skills. Exercise assessments are made for partial tasks, the final evaluation is a written test and assessment of calculation skills using methods of statistical physics.

STUDENT WORKLOAD:

- Participation in lectures: 15 hours
- Participation in exercises: 30 hours
- Preparation for the exercises: 30 hours
- Consulting for the lecturees and exercises: 5 hours
- Preparation for the completion of the lecture: 20 hours

TOTAL: 100 hours, 5 ECTS

Contact hours: 50 hours, 2.5 ECTS

RECOMMENDED READING:

[1] L. E. Reichl, *A Modern Course in Statistical Physics*, E. Arnold (Publishers) LTD, University of Texas Press 1980.

[2] J. J. Binney, N. J. Dowrick, A. J. Fisher, and M. E. J. Newman, *The Theory of Critical Phenomena. An Introduction to the Renormalization Group*, Clarendon Press, Oxford 1992.

OPTIONAL READING:

[1] F. Reif, *Fundamentals of Statistical and Thermal Physics*, Mc Graw-Hill, Singapore 1985.

[2] K. Huang, *Introduction to Statistical Physics*, CRC Press 2001.

PROGRAM PREPARATION:

Dr hab. Mirosław Dudek, prof. UZ

ASTROPHYSICS II

Course code: **13.7-WF-FizD-Astr2**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	30	2	II (AK)	Exam	
Class	30	2		Grade	

COURSE AIM:

An extension of the knowledge about stellar astrophysics, stellar evolution and binary stars evolution, and the final stages of the stellar evolution.

ENTRY REQUIREMENTS:

Basic knowledge in the field of astrophysics, namely the structure and evolution of stars. Basic knowledge of celestial mechanics.

COURSE CONTENTS:

- Final stages of stellar evolution.
- The basics of degenerated matter physics.
- Basic ideas of the General Relativity theory.
- White dwarves, neutron stars and black holes.
- Binary and multiple stars.
- Roche surfaces and Lagrange points.
- The types of binary systems: detached, semi-detached and contact.
- The evolution of close binary systems. Cataclysmic variables and X-ray binaries. \
- Astrophysics of the star clusters.
- Interstellar medium

TEACHING METHODS:

Classic lecture. Computational exercises during class plus a project method – an extended study of a selected topic from the lecture area of interest.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student has extended knowledge of the final stages of stellar evolution: white dwarves, neutron stars and black holes. He is able to explain how these objects properties are the outcome of the previous evolution. He can explain the observational properties of these objects based on their physical parameters. Student understands the differences between the solitary star evolution and the evolution in a binary system, and is able to explain them. He can describe the mechanics of a binary system, and its influence on the stellar evolution. He can explain how the mass transfer can affect the evolution of the stars in a binary. He can name and describe the standard types of binaries. Based on the current parameters of a binary star he can describe its earlier and future evolution. Student can characterize the types of stellar clusters, and describe their origin and evolution. He can Describe the basic components of the interstellar medium.	K2A_W01 K2A_W03	Oral exam	lecture
Using the acquired theoretical knowledge student can solve simple analytical problems concerning binary star and star cluster astrophysics. He can independently study a chosen topic from the field of stellar evolution or binary star astrophysics, using the available literature. He is able to present the results of his research in a written form.	K2A_U01 K2A_U03 K2A_U05 K2A_U07 K2A_U11 K2A_U12 K2A_U13 K2A_K01 K2A_K03	Written test, project grade	class

ASSESSMENT CRITERIA:

Final grade: weighted average of the exam grade (70%) and the class grade (30%).

Lecture: Oral exam passing condition – positive grade.

Class: written test – solving computational exercises (passing condition – positive grade), and a positive grade from the written research report.

STUDENT WORKLOAD:

- Participation in lectures: 15 x 2 = 30 h
- Participation in classes: 15 x 2 = 30 h
- Preparation for classes: 20 h
- Homework: 15 x 1 = 15 h
- Working on a research project: 20 h
- Consultations: 15 h
- Exam preparations: 10 h
- Participation in the exam: 2 h

TOTAL: 122 h, 6 ECTS.

Workload involving direct teacher participation: 67 h corresponding to 3 ECTS.

RECOMMENDED READING:

[1] F. Shu, *Galaktyki, gwiazdy, życie*, Prószyński i S_ka, 2003.

[2] M. Kubiak, *Gwiazdy i materia międzygwiazdowa*, PWN, 1994.

OPTIONAL READING:

[1] J. Mullaney, Double & Multiple Stars, and how to observe them, Springer 2005.
[2] R. Kippenhann, A. Weigert, *Stellar structure and evolution*, Springer 1996.

PROGRAM PREPARATION:

Dr Wojciech Lewandowski

EXTRAGALACTIC ASTRONOMY AND COSMOLOGY

Course code: **13.7–WF-FizD-APiKo**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Lecture	15	1	II (AK)	Grade	
Class	30	2		Grade	

COURSE AIM:

Knowledge of the current state of research on the structure and evolution of the Universe.

ENTRY REQUIREMENTS:

Basic knowledge of general relativity. Ability to program and use numerical methods

COURSE CONTENTS:

- Cosmological Principle (Copernican)
- Fundamental Cosmological Observations
- Components of the Universe: radiation, baryonic matter, dark matter and dark energy
- Evolution of the flat Friedman-Lemaitre models
- The formation of cosmic structures
- The comological parametrs
- CMB
- The evolution of galaxies and the Universe at high redshift
- The hypothesis of cosmic inflation
- Nucleosynthesis
- Active Galactic Nuclei

TEACHING METHODS:

Lecture and class

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Students can describe the standard cosmological model, Copernican principle and provide observations to justify its validity. They are able to	K2A_K01 K2A_K02	test, discussion	lecture

clasify galaxies and explain the differences between them. They can explain methods of determining the rotation curve of the Galaxy, and interpret its shape in the context of the existence and distribution of dark matter. Students know and understand the methods of estimating the age of galaxies. They know the evolution of galaxies, groups of galaxies (in particular the Local Group of Galaxies) , the theory of the Big Bang, the thermal history of the Universe and the fundamental cosmological models. They understand the expansion of the universe, the Hubble law, the importance of the cosmological constant and the microwave background radiation.They can describe the process of light elements after the Big Bang and the results of observational measurement of the abundance of light elements and their impact on the cosmological models.	K2A_K05 K2A_W01 K2A_W03 K2A_W04 K2A_W06 K2A_U01		
A student can perform, taking into account existing knowledge, calculations to solve basic problems and issues in extragalactic astrophysics and cosmology. Students are able to interpret astronomical observations. Can use their knowledge to construct a simple astrophysical research projects. A student understands the need for further training and is able to understand the lectures of specialists in the field of relativistic astrophysics. Can analyze astrophysical problems and formulate questions to have deeper understanding of problems arising in extragalactic astronomy and cosmology.. Can use his knowledge to give a lecture or write an article for general public – popularization of science. Is able to search for information in english literature.	K2A_W04 K2A_W05 K2A_U01 K2A_U02 K2A_U03 K2A_U05 K2A_U11 K2A_U12	current control, homework exercises, discussion, passing written tests	class

ASSESSMENT CRITERIA:

Lecture: Positive passing of final test.

Class: Handing in homework exercises, passing written tests. Positive marks of all activities.

Final grade: weighted average of the lecture test grade and class grade (50% and 50% respectively).

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 1 hour = 15 hours

- Participation in class: 15 weeks x 1 hours = 15 hours

- Preparation to classes: 15 x 1 hours = 15 hours

- Homework exercises: 15 x 1 hours = 15 hours

- Participation in the consultations: 10 hours

- Preparation for the test: 10 hours

TOTAL: 80 hours, 4 ECTS.

Workload involving direct teacher participation: 40 hours which corresponds to 2 ECTS.

RECOMMENDED READING:

[1] James B. Hartle, *Grawitacja*, 2009, ISBN 9788323504764.

[2] Barbara Rydel, *Introduction to Cosmology,* ISBN-13: 978-0805389128,
Addison-Wesley; 1st edition (October 18, 2002).

[3] P. Schneider, Extragalactic astronomy and Cosmology, Springer, 2006.

[4] A. Liddle, *Wprowadzenie do kosmologii współczesnej*, Prószyński i S-ka, 2000.

[5] M. Jaroszyński, *Galaktyki i budowa Wszechświata*, PWN, 1993.

OPTIONAL READING:

[1] Internet

PROGRAM PREPARATION:

Dr hab. Dorota Rosińska, prof. UZ

RADIATIVE PROCESSES IN ASTROPHYSICS

Course code: **13.7-WF-FizD-PrPwA**
Type of course: **compulsory**
Language of instruction: **English/Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					5
Lecture	30	2	II (AK)	Exam	
Class	45	3		Grade	

COURSE AIM:

The expansion of the knowledge of the theory of generation and propagation of radiation. To transfer messages from astrophysics allowing the students to understand on an advanced level most of the phenomena that involve the formation and evolution of the observed radiation from astronomical objects.

ENTRY REQUIREMENTS:

Knowledge of general astronomy, mathematical analysis and the basis of theoretical physics.

COURSE CONTENTS:

- The basic properties of radiation.
- The radiation flux.
    - Macroscopic description of the radiation transfere.
    - A stream of an isotropic source.
- The intensity of radiation and its moments.
    - The energy density of radiation.
    - Radiation pressure.
- The radiation transfer.
- The thermal radiation.
- Einstein coefficients.
- The scattering effects, random walking.
- The radiation diffusion.
- The basic theory of radiation field.
    - Polarization and Stokes parameters.
- Radiation from moving charges.
    - Lienard-Wiecharta potentials.
- Radiation reaction.
- Synchrotron radiation.

- Compton scattering.
- The plasma effects.

TEACHING METHODS:

The conventional lectures, the conventional classes.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Students can describe and discuss the fundamental laws of the radiation transfer, the physical processes responsible for the generation of electromagnetic waves and mutual interaction of waves and matter, with particular emphasis on those that apply to astrophysical issues. The student knows, understands and is able to describe the basic physical laws that govern the generations and propagation of radiation.	K2A_W01 K2A_U01	Oral examination	Lecture
The student has a basic knowledge on the polarization of electromagnetic waves and the Stokes parameters. He can name and describe the radiative processes occurring in the astronomical objects.	K2A_W01 K2A_W03 K2A_U01	Oral examination	Lecture
Taking into account their knowledge of the laws of physics, students can solve some the problems and issues of astrophysics. They are able to interpret simple observation of radiation sources and based on them estimate the most important physical parameters: brightness, size, temperature.	K2A_W01 K2A_U03	Written test	Classes
The student has a basic knowledge on the polarization of electromagnetic waves and the Stokes parameters. He can name and describe the radiative processes occurring in the astronomical objects.	K2A_U04	Written test	Classes

ASSESSMENT CRITERIA:

Lecture: Oral examination; Condition assessment - a positive mark of the exam.

Classes: Written test - positive mark of the test.

Final grade: weighted average of exam and class grades (70% and 30% respectively)

STUDENT WORKLOAD:

- Attendance of the lectures: 15 weeks x 2 hours = 30 hours
- Attendance of the classes: 15 x 3 = 45 hours
- Preparation for the classes: 15 x 1 = 15 hours
- Homework: 15 x 1 = 10 hours
- Participation in the consultations: 5 hours
- Preparation for the exam: 15 hours
- Participation in the exam: 2 hours
TOTAL: 127 hours, 5 ECTS

Workload involving direct teacher participation: 82 hours corresponding to 3 ECTS.

RECOMMENDED READING:

[1] Notatki z wykładów.
[2] G. Rybicki, A. Lightman, *Radiative processes in astrophysics*, John Wiley @ sons, 1979.

OPTIONAL READING:

[1] K. R. Lang, Astrophysical formulae, a compedium for the physicist and astrophysicist, Springer-Verlag 1980.
[2] V. L. Ginzburg, *Theoretical Physics and Astrophysics,* Pergamon Press PRES.

PROGRAM PREPARATION:

prof. dr hab. Giorgi Melikidze

PHYSICAL EDUCATION

Course code: **16.1-WF-FizD-WF**
Type of course: **optional**
Language of instruction: **Polish**
Director of studies: **mgr Tomasz Grzybowski**
Name of lecturer: **Teachers Physical Education and Sports Department**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					1
Class	30	2	III	Pass/Fail	

COURSE AIM:

Development of skills to meet the needs associated with the movement, physical fitness, and care for their own health.

ENTRY REQUIREMENTS:

-

COURSE CONTENTS:

General characteristics and basic rules of selected sport disciplines. Practical skills in selected sports. Health education through physical education and sport.

TEACHING METHODS:

Lectures, practical exercises, group activities

LEARNING OUTCOMES:

Knowledge: Student know the impact of physical activity on the proper functioning of the body; know the health risks resulting from unhygienic living; have a basic understanding of the rules and principles of playing different sports

Skills: Student is able to diagnose the state of his/her physical fitness; can use various forms of activities depending on the state of health, well-being, atmospheric conditions; carries out various forms of physical activity independently and is aware of its impact on the functioning of the body

Competence: Student is able to function in the group with the principles of social coexistence, responsibility for the safety of myself and others, helping less efficient is able to compete with the principles of "fair play", showing respect for the competitors and understanding for differences in the level of physical fitness; knows the health hazards due to the improper use of the sports equipment and appliances

LEARNING OUTCOMES VERIFICATION AND ASSESSMENT CRITERIA:

Exercise - credit on the basis of progress, commitment and student activities in classes and skills in the chosen sports.

Knowledge: observation of the student behaviour during the physical activity

Skills:

- Physical education (standard level) assessment of physical fitness and motor skills using standardized tests determining the level of motor development and technical skills
- Physical education (low level of physical fitness) evaluation of the student's knowledge of diagnostic methods for health and physical fitness and the ability to use exercise to improve movement dysfunction, physiological and morphological with the individual (depending on the type of disability) indicators of the body's functions

Competence: observation of the student behaviour in competitive Sports and in conditions that require the cooperation in the group

STUDENT WORKLOAD:

Contact hours: 30 hours, 1 ECTS

RECOMMENDED READING:

[1] M. Bondarowicz, *Zabawy i gry ruchowe w zajęciach sportowych*, Warszawa 2002.
[2] T. Huciński, E. Kisiel, *Szkolenie dzieci i młodzieży w koszykówce*, Warszawa 2008.
[3] R. Karpiński, M. Karpińska, *Pływanie sportowe korekcyjne rekreacyjne*, Katowice 2011.
[4] A. Kosmol, *Teoria i praktyka sportu niepełnosprawnych*, Warszawa 2008.
[5] T. Stefaniak, *Atlas uniwersalnych ćwiczeń siłowych*, Wrocław 2002.
[6] J. Talaga, *ABC Młodego piłkarza. Nauczanie techniki*, Warszawa 2006.
[7] J. Uzarowicz, Siatkówka. Co jest grane? Wrocław 2005
[8] B. Woynarowska, *Edukacja zdrowotna Podręcznik akademicki*, Warszawa 2010.
[9] J. Wołyniec, *Przepisy gier sportowych w zakresie podstawowym*, Wrocław 2006.

OPTIONAL READING: -

REMARKS: -

VARIETY IN UNITY IN BIOLOGICAL SCIENCES

Course code: **13.2-WF-FizD-RwJNP**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **prof. dr hab. Andrzej Drzewiński**
Name of lecturer: **prof. dr hab. Andrzej Drzewiński,**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					2
Lecture	30	2	III	Pass/Fail	

COURSE AIM:

The purpose of this course is to familiarize students with the development of concepts and methods of natural sciences, especially physics, chemistry and biology on historical background. Particular emphasis will be placed to indicate the characteristics common to modern methods associated with these different sciences. Thanks to accompanying multimedia presentations, verbal communication is illustrated with numerous examples.

ENTRY REQUIREMENTS:

Knowledge of the issues discussed during the first two semesters of study in physics.

COURSE CONTENTS:

- Origin of knowledge and its division
- Prehistory of sciences
- Natural sciences in the ancient times
- Natural sciences in the Middle Ages
- Foundations of modern science: experiment and quantitative laws
- From the Scientific Revolution to the Age of Enlightenment
- Birth of physiology and microbiology
- Dominance of classical physics
- Into the world of molecules
- Development of quantum physics and chemistry
- Great teams, great equipment, great discoveries
- Contemporary medical diagnostics
- Genetic Engineering
- Physics, chemistry and cosmology
- What is next and how to go from here?

TEACHING METHODS:

Teaching takes the form of lectures combined with discussion

LEARNING OUTCOMES. LEARNING OUTCOMES VERIFICATION:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student knows the stages of development	K2A_W01	The first part of a	lecture

of the life sciences with particular emphasis on physics, chemistry and biology. The student is aware of the coupling between the development and changes in the social, cultural and worldview. Student is able to specify the person who made the greatest contribution to the development of physics and astronomy, including the Polish scientists.	K2A_W03 K2A_U07 K2A_K02	final essay (two A4 pages)	
Student is able to identify common characteristics of scientific methods appropriate to natural science. Student understands the role of physics, in everyday life, but also is aware of the dangers posed by it.	K2A_W04 K2A_W06 K2A_U07 K2A_K03 K2A_K05	The second part of a final essay (two A4 pages)	lecture

ASSESSMENT CRITERIA:

Students are assessed on the basis of essay writing. The teacher provides the list of topics a month before the end of classes.

STUDENT WORKLOAD:

- Participation in the lecture: 15 x 2 = 30 hours
- Preparation to discuss: 15 x 1 = 15 hours
- Consultations: 2 hours

Total: 47 hours, 2 ECTS.

RECOMMENDED READING:

[1] *Dzieje nauki. Nauki ścisłe i przyrodnicze*, Wydawnictwa Szkolne PWN 2011.

[2] W. H. Brock, *Historia chemii*, Prószyński i S-ka, Warszawa 1999.

OPTIONAL READING:

[1] M. Bragg, R. Gardiner, *Na barkach gigantów. Wielcy badacze i ich odkrycia od Archimedesa do DNA*, Prószyński i S-ka, Warszawa 2005.

[2] A. Drzewiński, J. Wojtkiewicz, *Opowieści z historii fizyki*, PWN 2001.

[3] M. Friedman, G. W. Friedland, *Dziesięć największych odkryć w medycynie*, Prószyński i S-ka, Warszawa 2000.

[4] A. K. Wróblewski, *Historia fizyki*, PWN 2007.

PROGRAM PREPARATION:

Prof. dr hab. Andrzej Drzewiński

SOLID STATE PHYSICS

Course code: **13.2-WF-FizD-FFaSk**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					8
Lecture	30	2	III	Exam	
Class	45	3		Grade	

COURSE AIM:

The aim of the course is to provide students with basic knowledge of solid state physics and the corresponding research methods with the learning outcomes in the area of science. Students should know the basics of crystallography, the concept of reciprocal lattice, diffraction methods for determining the crystal structure, they should be familiar with the issue of an electron in a periodic potential, the question of the formation of the band structure in solids, the harmonic crystal approximation, they should know in detail the selected problems of condensed phase in the quantum description, including superconductivity.

ENTRY REQUIREMENTS:

It is assumed that students know subjects of general physics and they have got basic course of mathematical analysis (knowledge and skills that meet the criteria K2A_W01).

COURSE CONTENTS:

- Crystal lattices, the classification of Bravais lattices and crystal structures.
- Reciprocal lattice, diffraction methods to determine the crystal structure (Laue condition, Bragg equation, Brillouin zones, geometric structural factor).
- An electron in a periodic potential, the Bloch theorem, Kronig-Penney Model.
- Band theory of solids: metals, semiconductors and dielectrics, examples of band structures.
- Crystal in the harmonic approximation (classical and quantum theory), dispersion relations, normal modes in 1D monatomic Bravais lattices, one-dimensional chain with basis, acoustic and optical branches at Brillouin zone boundary.
- Selected issues: continuum linear elastic theory, wave propagation, specific heat, Debye model.
- Superconductivity.

TEACHING METHODS:

Teaching methods have two forms: lecture and exercises.
During the lecture both theory and selected examples are presented. Next, the examples are recommended to be extended at exercises. Students increase their computational skills by solving these examples in detail. In addition, they discuss selected problems.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Students have a basic knowledge of the methods of condensed matter physics. General knowledge is supported by a detailed skills in computing for selected models such as one-dimensional model Kröning-Penney'go one-dimensional chain of atoms - unions dispersion, specific heat, which allow broader understanding of the more general theoretical frameworks.	K2A_W01	test discussion exam	exercise exercise lecture
Students can explain and describe particular phenomena.	K2A_W01 K2A_W04	test discussion exam	exercise exercise lecture

ASSESSMENT CRITERIA:

The course ends with an exam grade. Examination is a written test of theoretical knowledge and practical skills in accounting. The effects of exercise training are reviewed by partial reviews on completed tasks, evaluation of written tests and assessment of accounting skills and understanding of selected topics of condensed matter physics.

Overall rating: arithmetic mean score of the exam and exercises.

STUDENT WORKLOAD:

- Participation in lectures: 30 hours
- Participation in exercises: 45 hours
- Preparation for the exercises: 45 hours
- Consulting for the lecturees and exercises: 5 hours
- Preparation for the completion of the lecture: 40 hours

TOTAL: 165 hours, 8 ECTS

Contact hours: 60 hours, 2,5 ECTS.

RECOMMENDED READING:

[1] Neil W. Ashcroft, N. David Mermin, *Solid State Physics*, Harcourt College Publishers 1976

[2] C. Kittel, *Introduction to solid state physics*, John Wiley& Sons Inc, 1996.

[3] L. E. Reichl, *A Modern Course in Statistical Physics*, E. Arnold (Publishers) LTD, University of Texas Press 1980.

OPTIONAL READING:

[1] Donald A. MCQuarrie, *The Kroning-Penney Model: A Single Lecture Illustrating the Band Structure of Solids*, in The Chemical Educator VOL. 1. 1996 Springer-Vellag New York, inc.

[2] F. Reif, *Fundamentals of Statistical and Thermal Physics*, Mc Graw-Hill, Singapore 1985.

PROGRAM PREPARATION:

Dr hab. Mirosław Dudek, prof. UZ

NUCLEAR AND HIGH ENERGY PHYSICS

Course code: **13.2-WFiA-FizD-FJFWE**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	30	2	III	Exam	
Class	30	2		Grade	

COURSE AIM:

Introduction to fundaments of nuclear physics and high energy physics.

ENTRY REQUIREMENTS:

Basic knowledge of classical and quantum mechanics.

COURSE CONTENTS:

- Subjects of nuclear physics and high energy physics
- Physical quantities characterizing nuclei and elementary particles; mass, charge, life-time, barion and lepton numbers, spin, magnetic moment, isospin, parity.
- Nucleon-nucleon interaction. Theory of deuteron.
- Nuclear models: Liquid Drop Model, Fermi gas model, shell model, self-consistent model.
- Mean field theory. Nuclear potentials.
- Residual interactions, quasi-spin model, BCS theory.
- Collective motion. Rotational and vibrational excitations.
- Spontaneous decay of nuclei; α, β, γ, fission.
- Nuclear reactions, Collisions with low, medium and high energies.
- Elements of the standard model and high energy physics.

TEACHING METHODS:

Lectures on problems and discussions. Oral practice, in which students solve tasks.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES

The student knows and understands the fundamental properties of atomic nuclei	K2A_W01 K2A_U01	Disscussion, tests, exam	Class
The student knows mean field approach to many body problem	K2A_W06	Disscussion, tests, exam	Class
The student understands several models applicable in nuclear physics: liquid drop model, Fermi gas model. The student is able to estimate basic nuclear propertis on the ground of those models	K2A_U03	Disscussion, tests, exam	Class
The student knows general mechanisms of nuclear reactions and recognizes collective excitations	K2A_W03 K2A_U03	Disscussion, tests, exam	Class
The student knows elementary particles according to the standard model	K2A_W05	Disscussion, tests, exam	Class

ASSESSMENT CRITERIA:

A course credit for the lectures is obtained by taking a final exam composed of tasks of varying degrees of difficulty.

During the classes the preparation of the students will be checked as well as their understanding of the lecture content at the time of the lectures. To obtain a course credit for the exercises 50% of the maximum number of points will be required, which can be achieved through two cumulative tests. A student who achieves at least 10% of the maximum points and who does not exceed the class absence limit has the right to a resit test of the entire material before the examination date. The result of the exam is also affected by class participation and preparation for the class.

STUDENT WORKLOAD:

Contact hours:

- Lectures: 30 hours
- Exercises: 30 hours
- Consultation: 2 hours
- Exam; 2 hours

Total: 64 hours, 3 ECTS.

Individual workload of student:

- Preparation for lectures: 8 hours
- Preparation for exercises: 20 hours
- Preparation for tests: 15 hours
- Preparation for exam: 15 hours

Total: 58 hours, 3 ECTS.

Final total: 122 hours, 6 ECTS.

RECOMMENDED READING:

[1] P. Rozmej*, Lecture Notes,* plik pdf.

[2] B. Nerlo-Pomorska, K. Pomorski, *Zarys teorii jądra atomowego,* PWN, Warszawa 1999.

OPTIONAL READING:

[1] E. Skrzypczak, Z. Szefliński, *Wstęp do fizyki jądra atomowego i cząstek elementarnych*, PWN, Warszawa 1995.

[2] W. S. C. Williams, *Nuclear and particle physics*, Oxford: Clarendon Press, 1997.

PROGRAM PREPARATION:

Prof. dr hab. Piotr Rozmej

INTERNET APPLICATIONS PROGRAMMING

Course code: **11.3-WF-FizD-PrApl**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Lecture	15	1	III (FK)	Exam	
Laboratory	30	2		Grade	

COURSE AIM:

The aim of this course is to introduce the programming techniques required to develop and create internet applications – how to design and code frontend in css and html, hot to store and analyse data (relational databases). Open source software is important part of this course.

ENTRY REQUIREMENTS:

basic programming in python (with OOP)

relational databases on the basic level

COURSE CONTENTS:

1. HTML
   - document structure
   - blok and „in-line" elements
   - data presentation
   - links
   - graphics
   - lists
   - tables
   - forms
   - HTML 5
2. CSS
   - selectors
   - data formating
   - box model
   - positioning
   - layouts
   - menu

3. JQuery
   - JavaScript – introduction
   - JQuery – introduction
   - Jquery UI
   - Plugins
   - Ajax
4. Django framework
   - Python – OOP techniques
   - Django installation and configuration
   - view and urls
   - models and relational databases
   - admin panel
   - forms

TEACHING METHODS:

Lecture:

Convencional lecture, work with problems, discusiion, workshop

Laboratory:

Laboratory exercise, project, work in group, presentation, work with documentation, independed work, brain storm

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student can find, choose and use external libraries, frameworks and other solutions according to the licences and the law. Student can describe what OpenSource means and discuss why Open Source Software is a good alternative to commercial software and why is worth to use.	K2A_W09 K2A_U09 K2A_U10 K2A_K04	activity during laboratories, project, discussion, exam	laboratory, lecture
Student can prepare web page according to the W3C standards. Student can discuss why data and presentation layer should be separated.	K2A_W09 K2A_U09 K2A_U10 K2A_K04	activity during laboratories, project, discussion, exam	laboratory, lecture
Student can design database based internet service and create it in Django framework. Student can discuss role of the database web services in modern world.	K2A_U09 K2A_U10 K2A_K04	activity during laboratories, project, discussion, exam	laboratory, lecture

ASSESSMENT CRITERIA:

Lecture:

final procject – 40% (Html + CSS + Jquery), 40% design, quality of code, 20% presentation and discussion.

Laboratory:

20% - tests during laboratories
40% - frontend project
40% - Django project

STUDENT WORKLOAD:

- Lectures: 15 h
- Laboratories: 30 h
- Preparation for laboratory: 20 h
- Project preparation: 25 h
- Consultation: 3 h
- Exam: 1 h

Sum: 94 h, 4 ECTS.

Lecturer direct participation: 49 h, 2 ECTS.

RECOMMENDED READING:

[1] http://www.w3.org/Style/Examples/011/firstcss
[2] http://www.w3schools.com/
[3] http://docs.jquery.com/Tutorials
[4] http://www.djangobook.com/
[5] https://docs.djangoproject.com/en/1.3/

OPTIONAL READING:

[1] http://www.smashingmagazine.com/
[2] Internet

PROGRAM PREPARATION:

Dr Marcin Kośmider

ADVANCED SPECTROSCOPIC METHODS

Course code: **13.2-WF-FizD-ZaTSp**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Lecture	15	1	III (FŚ)	Exam	
Laboratory	30	2		Grade	

COURSE AIM:

In-depth knowledge of modern methods, techniques and equipment of the magnetic resonance spectroscopy including nuclear magnetic resonance (NMR), electron paramagnetic resonance and ferromagnetic resonance (EPR and FMR) and optical spectroscopy for the study of various substances in the physics of environment.

ENTRY REQUIREMENTS:

Basic knowledge of modern physics, including foundations of electrodynamics, atomic and nuclear physics, quantum mechanics in the framework of university courses as well as methods of modern experimental physics, in particular, optical and magnetic resonance spectroscopy.

COURSE CONTENTS:

Lecture:

Classification and short description of magnetic resonance spectroscopy methods.
Nuclear magnetic resonance (NMR). The experimental techniques and applications of NMR spectroscopy.
Diamagnetic, paramagnetic, and superparamagnetic solids. Ordered magnetic structures in solids, their classification and models.
Magnetic resonance spectroscopy of solids. EPR study of the electronic and local structure of the paramagnetic centres. The FMR investigations of the magnetically-ordered solids and magnetic nanocomposites.
Optical properties of ordered (crystalline) and disordered (glassy or vitreous) undoped solids. Optical absorption and intrinsic luminescence of crystals and glasses. Inter-band transitions.
Impurity states in solids. Ions of transition and rare-earths metals groups in crystals and glasses. The energetic structure of the transition and rare-earth ions in the crystal field. Optical and EPR spectroscopy of ions of the transition and rare-earths groups in crystals and glasses.
Intrinsic and radiation-induced point defects in crystals and glasses, their classification and models.
Spectroscopic methods (EPR, optical absorption, photoluminescence, thermoluminescence and other) of investigations of the electronic and local structure of intrinsic and radiation-induced point defects in solids.

Laboratory:

Registration, analysis and interpretation of the EPR spectra of transition ions in crystals and glasses.
Registration, analysis and interpretation of the EPR spectra of rare-earth ions in crystals and glasses.
Registration, analysis and interpretation of the FMR spectra of magnetic nanoparticles of iron group elements and their oxides of various compositions.

Registration, analysis and interpretation of luminescence spectra (excitation and emission) and the kinetics of luminescence of the transition ions in crystals and glasses.
Registration, analysis and interpretation of luminescence spectra (excitation and emission) and the kinetics of luminescence of the rare-earth ions in crystals and glasses.
Registration, analysis and interpretation of EPR spectra of the radiation-induced point defects in crystals and glasses.

TEACHING METHODS:

Conventional lecture. Working with books including special monographs and original articles in the scientific journals.
Laboratory works.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
He knows the experimental and observational techniques along with their limitations.	K2A_W03	Grade	Laboratory
He knows the theoretical basis for the operation of scientific instruments in the field of scientific fields and disciplines relevant to physics.	K2A_W04	Exam	Lecture
He knows the rules of safety and health at work sufficiently to work independently in a profession physics.	K2A_W07	Grade	Laboratory
Able to plan and carry out basic experiments or observations about physical problems.	K2A_U02	Grade	Laboratory
Can understand the problems of areas of knowledge common to physics and science related to it as chemistry and biology.	K2A_U07	Exam	Lecture
Understands the need to learn throughout their lives, can inspire and organize the learning process of others.	K2A_K01	Exam	Lecture
Is aware of the social impact of research typical of physics.	K2A_K05	Exam	Lecture

ASSESSMENT CRITERIA:

Laboratory: the presence and active participation in lab works, pass on a positive assessment of laboratory reports within the prescribed period.

Examination of the course: a positive evaluation of the oral examination of the full range of material.

Overall rating: Arithmetic means pass the exam and laboratory.

STUDENT WORKLOAD:

- Participation in lectures: 15 h.
- Participation in lab works: 30 h.
- Prepare for lab works: 30 h.
- Preparation for exam: 20 h.
- Consultation and participation in exam: 5 h.

Total: 100 h, 4 ECTS credits.

Efforts associated with activities that require direct participation of teachers: 50 h, 2 ECTS.

RECOMMENDED READING:

[1] J. A. Weil, J. A. Bolton. J. E. Wertz, *Electron Spin Resonance. Elementary Theory and Practical Applications*, John Wiley & Sons, New York 1994.

[2] B. Henderson, G. F. Imbush, *Optical Spectroscopy of Inorganic Solids*, Clarendon Press, Oxford 1989.

OPTIONAL READING:

[1] Special literature (monographs and original articles) on investigations of different substances by modern methods of the magnetic resonance and optical spectroscopy.

REMARKS:

Before taking the exam a student must obtain a pass from the laboratory.

PROGRAM PREPARATION:

Dr hab. Bohdan Padlyak, prof. UZ

QUANTUM PHYSICS II

Course code: **13.2-WF-FizD-FKwa2**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Lecture	15	1	III (FT)	Exam	
Class	30	2		Grade	

COURSE AIM:

To teach the student several general features of quantum systems. To give foundations for various possible applications

ENTRY REQUIREMENTS:

Knowledge of first and second course of quantum mechanics

COURSE CONTENTS:

LECTURE:

- The density operator
- The evolution operator
- Gauge invariance
- Unstable states; lifetimes
- Bound sates of a particle in a potential well of arbitrary shape
- Unbound states of a particle in the presence of a potential well or barrier of arbitrary shape

CLASS:

Essentially the same topics, but with extension of particular calculations and interpretations on several examples.

TEACHING METHODS:

Lectures on problems and discussions. Oral practice, in which students solve tasks.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student is aware of	K2A_W01	Disscussion, tests, exam	Class

importance of density operator in quantum mechanics			
The student knows gauge invariance and its consequences	K2A_W02	Disscussion, tests, exam	Class
The student knows methods of studying time evolution of quantum systems	K2A_U01	Disscussion, tests, exam	Class
The student is familiar with unbound states of physical systems their decay and lifetimes	K2A_U10	Disscussion, tests, exam	Class
Is able to study both bounded and unbounded states of a particle in arbitrary potential	K2A_U03	Disscussion, tests, exam	Class

ASSESSMENT CRITERIA:

LECTURE: A course credit for the lectures is obtained by taking a final exam composed of tasks of varying degrees of difficulty.

CLASS: During the classes the preparation of the students will be checked as well as their understanding of the lecture content at the time of the lectures.

To obtain a course credit for the exercises 50% of the maximum number of points will be required, which can be achieved through two cumulative tests. A student who achieves at least 10% of the maximum points and who does not exceed the class absence limit has the right to a re sit test of the entire material before the examination date. The result of the exam is also affected by class participation and preparation for the class.

Entrance to the exam requires prior accreditation of the course exercises.

STUDENT WORKLOAD:

Contact hours:

- Lectures: 15 hours
- Exercises: 30 hours
- Consultation: 5 hours
- Exam: 2 hours

Total: 52 hours, 2 ECTS

Individual workload of student:

- Preparation for lectures and exam: 15 hours
- Preparation for exercises and tests: 30 hours

Total: 97 hours, 4 ECTS.

RECOMMENDED READING:

[1] C. Cohen-Tannoudji, B. Diu, F. Laloe, *Quantum Mechanics,* 1992.

[2] I. Białynicki-Birula, M. Cieplak, J. Kamiński, *Theory of quanta,* PWN, Warszawa 2001.

[3] Pdf file delivered to the students.

OPTIONAL READING:

[1] A. L. Schiff, *Quantum mechanics,* PWN, Warszawa 1987.

PROGRAM PREPARATION:

Prof. dr hab. Piotr Rozmej

MODERN RADIO ASTRONOMY

Course code:	**13.7-WF-FizD-RadWs**
Type of course:	**compulsory**
Language of instruction:	**English/Polish**
Director of studies:	**The academic teacher giving the lecture**
Name of lecturer:	**Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					2
Lecture	30	2	III (AK)	Grade	

COURSE AIM:

Gaining knowledge about modern radio astronomy. Overview modern research instruments and techniques of observation. Presentation of the current knowledge about the radio sources in the universe. Overview of key research projects XXI century astronomy.

ENTRY REQUIREMENTS:

Radio astronomical fundamentals

COURSE CONTENTS:

Modern techniques of observations in radio astronomy. Construction and operation of modern telescopes. Interferometry. Radio sources in the Universe. Projects: ALMA, FAST, LOFAR, SKA.

TEACHING METHODS:

Lecture

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
1. The student is able to define and explain the fundamental problems of radio astronomy	K2A_W02	Discussion/test	Lecture
2. Student can discuss the modern tools and techniques of observation in radio astronomy	K2A_W04, K2A_W06	Discussion/test	Lecture
3. Student can discuss the basic properties of radio sources.	K2A_W06 K2A_K01	Test	Lecture
4. Student can describe the projects: ALMA, FAST, LOFAR and SKA.	K2A_W06 K2A_K01 K2A_K05	Discussion/test	Lecture

ASSESSMENT CRITERIA:

Final grade: Written test. Positive passing of final test (80%) and discussion (20%).

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 2 hours = 30 hours

- Preparation for the lecture: 10 hours

- Participation in the consultations: 2 hours

- Preparation for the test: 10 hours

TOTAL: 52 hours, 2 ECTS.

Workload involving direct teacher participation: 32 hrs corresponding to 1 ECTS.

RECOMMENDED READING:

[1] *Astronomia popularna*, praca zbiorowa, PWN, Warszawa 1990.
[2] F. H. Shu, *Fizyka Wszechświata*, Prószyński i S-ka, Warszawa 2003.
[3] J. D. Kraus, 1986, *Radio Astronomy*, 2nd edition, Cygnus-Quasar Books, Powell, OH.
[4] T. L. Wilson, K. Rohlfs, S. Huttemeister, *Tools of Radio Astronomy*, Fifth Edition, Springer-Verlag, Berlin 2009.
[5] B. F. Burke and F. Graham-Smith, *An Introduction to Radio Astronomy*, Third Edition, Cambridge University Press, 2010.

OPTIONAL READING:

[1] *D. Lorimer and M. Kramer*, *Handbook of Pulsar Astronomy*, Cambridge University Press, Cambridge, 2005.

[2] Single-dish radio astronomy techniques and applications: proceedings of the NAIC-NRAO Summer School held at National Astronomy and Ionosphere Center, Arecibo Observatory, Arecibo, Puerto Rico, USA, 10-15 June 2001.
[3] A. R. Thompson, J. M. Moran, G.W. Swenson Jr., *Interferometry and Synthesis in Radio Astronomy*, Second Edition; WILEY-VCH Verlag GmbH & Co. KgaA, Weinheim, 2004.

PROGRAM PREPARATION:

Dr hab. Jarosław Kijak, prof. UZ

HIGH-ENERGYASTROPHYSICS

Course code: **13.7-WF-FizD-AsWEn**

Type of course: **compulsory**

Language of instruction: **English/Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
Full-time studies PHYSICS – second degree studies					2
Lecture	30	2	III (AK)	Exam	

COURSE AIM:

Consolidation and expansion of the basic concepts of high-energy astrophysics. Forward the message to enable the understanding of high-energy astrophysical processes.

ENTRY REQUIREMENTS:

Knowledge from the introduction to astrophysics, compact objects, Astrophysics I and II.

COURSE CONTENTS:

- Special Theory of Relativity.
- Physics of fluids.
- Radial processes.
- Star supernovae.
- Neutron stars, pulsars and magnetars.
- Binary systems of compact objects.
- Gamma-ray bursts and gamma-ray burst afterglow.
- Active Galactic Nuclei.

TEACHING METHODS:

Lecture with exercises conventional accounting

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student knows and understands the cource content.	K2A_W03 K2A_W04 K2A_W06	Exam	Lecture
Student is able to carry out the bills for solving problems and issues high-	K2A_U02	Exam	Lecture

energy astrophysics. Able to interpret astronomical observations carried out in the X-and gamma of the electromagnetic spectrum, and on this basis to estimate the most important physical parameters such as binary systems with a compact object as one of the ingredients.	K2A_U03 K2A_U07		
Student is able to use their knowledge to construct a simple research projects, as well as to present their knowledge in a popular science.	K2A_K05	Exam	Lecture
Student can use the English-language literature.	K2A_U14 K2A_K01	Exam	Lecture

ASSESSMENT CRITERIA:

Final grade: Oral examination, Condition Assessment - a positive evaluation of the test

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 2 hours = 30 hours
- Preparation for the lecture: 10 hours
- Participation in the consultations: 2 hours
- To prepare for the exam: 10 hours
- Participation in the exam: 2 hours

TOTAL: 54 hours, 2 ECTS.

Workload involving direct teacher participation: 34 hours corresponding to 1 ECTS.

RECOMMENDED READING:

[1] U. Kolb, *Extreme Environment Astrophysics*, Cambridge, 2010.
[2] S. Rossweg, M. Brueggen, *Introduction to High-Energy Astrophysics*, Cambridge, 2007.
[3] M. S. Longair, *High Energy Astrophysics*, Cambridge, 2011.

OPTIONAL READING:

[1] M. Camenzind, *Compact objects in astrophysics*, Springer, 2007.
[2] W. H. G. Lewin, M. van der Klis, *Compact Stellar X-ray Sources*, Cambridge Uni. Press, 2006.
[3] F. Shu*, Galaktyki, gwiazdy, życie*, Prószyński i S-ka, 2003.

PROGRAM PREPARATION:

Dr Agnieszka Słowikowska

GRADUATE SEMINAR I

Course code: **13.2-WF-FizD-Smgr1**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher directing the seminar**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Class	30	2	III	Grade	

COURSE AIM:

To teach students how to prepare and show the presentation involving results discussed in MSc thesis. Preparation for writing MSc thesis.

ENTRY REQUIREMENTS:

Skills and knowledge gained during completed courses.

COURSE CONTENTS:

Elements of topics in the field of contemporary physics (with special emphasis on those discussed in students' MSc theses).

TEACHING METHODS:

Preparation of talks related to MSc thesis. Joint discussion concerning the merit and form of the presentations.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

The student gains a general knowledge in the field of current developments and latest discoveries in the physical sciences (**K2A_W06**). He/she can adapt the his presentation to the level of recipient's knowledge (**K2A_U01**), acquire by oneself his knowledge and to develop skills using a variety of sources (in Polish and foreign language) and modern technology (**K2A_U10**). The student gains the ability to prepare oral presentations, in Polish and foreign language in the fields typical for both theoretical and experimental physics (**K2A_U13**). He/she understands the role of active and passive dissemination of the knowledge (**K2A_K02**).

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student gains a general knowledge in the field of current developments and latest discoveries in the physical sciences	K2A_W06	Preparation and presentation of talks. Active participation in discussions.	seminar
The student can adapt the his	K2A_U01	Preparation and presentation of	seminar

presentation to the level of recipient's knowledge		talks.	
The student is able to acquire by oneself his knowledge and to develop skills using a variety of sources (in Polish and foreign language) and modern technology	K2A_U10	Preparation and presentation of talks.	seminar
The student gains the ability to prepare oral presentations, in Polish and foreign language in the fields typical for both theoretical and experimental physics	K2A_U13	Preparation and presentation of talks.	seminar
The student understands the role of active and passive dissemination of the knowledge.	K2A_K02	Preparation and presentation of talks. Active participation in discussions.	seminar

ASSESSMENT CRITERIA:

Preparation and presentation at least two talks related to the topis discussed in classes. Active participation in discussions concerning presented talks.

STUDENT WORKLOAD:

- Participation in classes - 30 hours
- Preparing presentations - 50 hours
- Consultations - 5 hours

Total: 85 hours, 4 ECTS.

Effort related to activities requiring direct participation of teachers 35 hours - equivalent to 2 ECTS.

RECOMMENDED READING:

[1] Articles recommended by lecturer, published in scientific and popular journals

[2] Scientific articles downloaded from the server: lanl.arxiv.org.

OPTIONAL READING: -

PROGRAM PREPARATION:

Dr hab. Wiesław Leoński, prof. UZ

MONOGRAPHIC LECTURE I – INTRODUCTION TO QUANTUM INFORMATION THEORY

Course code: **13.2-WF-FizD-WyMo1**
Type of course: **compulsory**
Language of instruction: **Polish or English (to be chosen)**
Director of studies: **dr hab. Van Cao Long, prof. UZ**
Name of lecturer: **dr hab. Van Cao Long, prof. UZ**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					5
Lecture	30	2	III	exam	

COURSE AIM:

Acquaint students with foundations of Quantum Information Theory: Mathematical tools of this Theory and possible physical realizations of quantum computers.

ENTRY REQUIREMENTS:

Knowledge of mathematics and quantum mechanics found from the previous period of study.

COURSE CONTENTS:

- Mathematical foundations of quantum calculations
    - Vectors and operators in Hilbert space
    - Postulates of quantum mechanics
    - Two paradoxes of quantum mechanics: Schroedinger's cats and Einstein-Podosky-Rosen pairs
    - Qubits and quantum registers. Entangled states
    - Quantum gates
    - Quantum algorithms. Teleportation. Shor's algorithm
- What is the quantum computer?
    - Two-level atom as a qubit
    - Optical Bloch equations, quantum gates as rotations on Bloch Sphere
    - Photon as a qubit
    - How quantum computer works
    - Quantum addition and multiplication
- Quantum cryptography
    - Fundamental concepts of cryptography
    - Quantum key distribution by polarized photons
    - Attack on the Rivest-Shamir-Adleman cryptosystem
- Conclusions

TEACHING METHODS:

Conventional lecture with the application of multimedia devices.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Knowledge: Student possesses a general knowledge concerning quantum information on the both mathematical and physical levels appropriate to the knowledge obtained in the previous period of studies. Lecture is a short introduction to the fundamental problems of the scientific domain which develops very fast in the last time, namely the quantum information theory. Its applications are also considered, in particular quantum cryptography.	K2A_W02 K2A_W06	Grade of the final exam	Participation on the lecture
Ability: Student can analyze and solve some simple problems in quantum information theory, in particular in quantum cryptography, based on the knowledge and information obtained from the literature, data bases, internet resources in both polish and English, he can present different physical realizations of quantum computers by a simple comprehensible language. He will able to perform the analysis of results for some algorithms (e.g. teleportation protocol, Shor's algorithm…), and based on this he can formulate proper conclusions. He could also find himself a necessary knowledge and develop his abilities in this new domain using different sources of information.	K2A_U01 K1A_U01 K2A_U06 K2A_U10	As above	As above
Social competences: Student has an awareness about his knowledge and abilities, understand the need and know the possibilities of continuous gain own qualifications (studies of second and third degree, postgraduate studies) – raising the personal, professional and social qualifications.	K2A_K01	As above	As above

ASSESSMENT CRITERIA:

The condition for credit is a positive grade of the final exam. This grade is also the final grade.

STUDENT WORKLOAD:

- Participation on the lecture: 30 hours
- Independent work: 60 hours
- Consultations: 10 hours
- Participation in the exam: 2 hours

In sum: 102 hours, 5 ECTS.

RECOMMENDED READING:

[1] M. A, Nielsen, I. L. Chuang, *Quantum Computation and Quantum Information*, Cambridge University Press, Cambridge, UK 2000.

[2] K. Giara, M. Kamiński M, *Wprowadzenie do algorytmów kwantowych*, Akademicka Oficyna Wydawnicza EXIT, Warszawa 2003.

OPTIONAL READING:

[1] D. Bouwmeeste, A. Ekert, A. Zeilinger (red.), *The Physics of Quantum Information*, Springer-Verlag, Heidenberg 2000.

PROGRAM PREPARATION:

Dr hab. Cao Long Van, prof. UZ

QUANTUM SYSTEMS SIMULATIONS

Course code: **11.3-WF-FizD-SyUKw**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	30	2	IV (FK)	Exam	
Laboratory	30	2		Grade	

COURSE AIM:

Students should know the methods of numerical simulation of quantum systems and how to applie them to selected problems of quantum mechanics and quantum computing.

ENTRY REQUIREMENTS:

Knowledge of quantum mechanics, knowledge of mathematical methods of physics, knowledge of programming languages - the knowledge and skills that meet the criteria K2A_W01.

COURSE CONTENTS:

1. Quantum Mechanics:
- Wavepackets (Gaussian wavepacket, diffraction, tunneling),
- Simulation using quantum chemistry methods (orbitals, Slater determinant, Hartree-Fock equations, DFT method),
- Simulations using quantum Monte Carlo.
2. Selected aspects of quantum information (qubit concept, arithmetic operations on qubits, quantum algorithms).

TEACHING METHODS:

Teaching methods take the form of lecture, computer lab and excersises. The lecture is is for theoretical introduction. It wshould be enriched with examples of computer simulations and indications of how and when to use quantum methods. The laboratory should have a practical nature, where students are discussing the lecture material, prepare simulations of simple quantum systems, become familiar with the available libraries to conduct simulations of quantum systems. The suggested programming language - Python.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES

Students have a basic knowledge of the methods of computer simulation of quantum systems. General knowledge.	K2A_W01	test discussion exam	exercise exercise lecture
General knowledge is supported by the ability to implement a detailed quantum model simulations. They can explain the quantum of phenomena under consideration and justify the methods to be used. They have elementary knowledge of quantum computing.	K2A_W01 K2A_W04	test discussion exam	exercise exercise lecture

ASSESSMENT CRITERIA:

The lecture ends with an examination to be assessed. Form of a check is a written theoretical problem and practical skills in its implementing. The effects of exercise training are verified by partial rankings on completed tasks, evaluation of written tests and assessment of skills in computer simulation for a specific issue of quantum problem.

Overall rating: arithmetic average exam grade and credit.

STUDENT WORKLOAD:

- Participation in lectures: 30 hours
- Participation in exercises: 30 hours
- Preparation for the exercises: 30 hours
- Preparation to exam: 25 hours
- Consulting for the lecturees and exercises: 5 hours
- Exam: 2 hours

TOTAL: 122 hours, 6 ECTS.

Contact hours: 67 hours, 3 ECTS.

RECOMMENDED READING:

[1] W. M. C. Foulkes, L. Mitas, R. J. Needs , G. Rajagopal, *Reviews of Modern Physics*, Vol. 73, No. 1, January 2001

[2] Leonard I. Schiff, *Quantum Mechanics*, McGrawHill Book Company (1968)

OPTIONAL READING:

[1] Internet, python libraries.

PROGRAM PREPARATION:

Dr hab. Mirosław Dudek, prof. UZ

ANTENNAS RADIATION

Course code: **13.2-WF-FizD-PrAnt**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	30	2	IV (FŚ)	Exam	
Laboratory	30	2		Grade	

COURSE AIM:

The aim of the course is to familiarize students of physics who specialize in environmental physics with the issue of antenna radiation. This will include theoretical introduction to antennas, examples of their applications. Students should be able to define the antenna, get to know the methods of measurement of antenna radiation, they should recognize the different types of antennas, learn about issues related to the impact of antenna radiation on human health and they should know regulations in this regard.

ENTRY REQUIREMENTS:

Knowledge of general physics.

COURSE CONTENTS:

- Electromagnetic waves and antennas - basic concepts, types of antennas.
- Antenna radiation patterns.
- Polarization, energy gain, impedance.
- Methods for measuring antenna radiation characteristics.
- Effects of electromagnetic fields on human health legislation.

TEACHING METHODS:

Basic methods of training includes lecture and laboratory. Laboratory activity is both mathematical and practical. Students have access to the measuring apparatus which allows the measurement of radiation characteristics of selected antennas.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Students know the principles of antennas, they can distinguish them.	K2A_W01 K2A_W03	test discussion exam	exercise exercise lecture
Students can in a practical way to measure radiation for selected antennas.	K2A_U01 K2_U02	test discussion	exercise exercise
Students are aware of the impact of electromagnetic radiation on health.	K2A_U07 K2A_K05	test discussion	exercise exercise

ASSESSMENT CRITERIA:

The course ends with an exam grade. Exam is a written test of theoretical knowledge and practical skills in accounting. The exercises in the lab learning outcomes are reviewed by partial reviews on completed tasks, evaluation of written tests and accounting of the level of practical skills in the use of measuring equipment.
Overall rating: arithmetic mean score of the exam and lab pass.

STUDENT WORKLOAD:

- Participation in lectures: 30 hours
- Participation in exercises: 30 hours
- Preparation for the exercises: 30 hours
- Consulting for the lecturees and exercises: 5 hours
- Preparation for the completion of the lecture: 25 hours

TOTAL: 120 hours, 6 ECTS.

Contact hours: 65 hours, 3 ECTS

RECOMMENDED READING:

[1] Constantine A. Balanis, *Antenna theory. Analysis and design*, John Wiley & Sons, Inc. 2005.

[2] R. K. Singh, *Estimation of Electromagnetic Radiation from Base Station Antenna*, International Journal of Medical and Biological Sciences 6, 2012.

[3] Stanisław Marzec, Adam Stawowy, *Narażenie ludności na pole elektromagnetyczne anten telefonii komórkowej*, Zeszyty Naukowe Wyższej Szkoły Zarządzania Ochroną Pracy w Katowicach, Nr 1(3)/2007, s. 45-54.

OPTIONAL READING:

[1] Hugh D. Young, Roger A. Freedman, A. Lewis Ford. University Physics, 2008 Pearson Education, Inc.

PROGRAM PREPARATION:

Dr hab. Miroslaw Dudek, prof. UZ

IONIZING RADIATION AND RADIOLOGICAL PROTECTION

Course code: **13.2-WF-FizD-PJiOR**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher giving the lecture**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					2
Lecture	30	2	IV	Grade	

COURSE AIM:

The aim of the course is to familiarize students with the physical description of influence of of ionizing radiation on living organisms and elements of radiological protection.

ENTRY REQUIREMENTS:

Fundamentals of Physics and in particular Fundamentals of Physics III - Electricity and magnetism, Fundamentals of Physics IV - Optics and Modern Physics and Mathematical Analysis I and II.

COURSE CONTENTS:

Sources and types of nuclear radiation, corpuscular and wave nature of nuclear radiation. Natural and artificial radioactivity, the laws governing the phenomenon of radioactivity. Mechanisms of interaction of heavy charged particles, electrons, photons and neutrons with matter

X-rays, its generation and applications

Influence of ionizing radiation on living organisms. Sources of ionizing radiation. Ionization and excitation of matter under the influence of ionizing radiation. Detectors of ionizing radiation. Dosimetry of ionizing radiation. Biological effects of ionizing radiation. The values of permissible doses of ionizing radiation.

Natural radioactivity. Cosmic radiation, radionuclides, radon and thoron, radionuclides in living organisms. The use of radionuclides .

Nuclear energy - models of atomic nuclei, binding energy, activation energy, fission and fusion of atomic nuclei, chain reaction, nuclear power, nuclear reactors, nuclear fuel, modern nuclear power plants, nuclear power in the global system of production and consumption of energy.

Radiation protection - protection against ionizing radiation, the types and effectiveness of fixed shieldss, weakening of the radiation intensity, safe distance from the exposed radiation sources, limited time zone, emergency zone, causes and consequences of a failure in nuclear installations, radioactive contamination and waste, pprogram of nuclear safety and emergency plans

TEACHING METHODS:

Conventional lecture.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student should demonstrate a good knowledge of the properties of nuclear radiation, the laws governing natural and artificial radioactivity. Students understand the notions and the physical quantities used for description of the ionizing radiation phenomena.	K2A_W01	Exam, test	Lectures
The student knows principles of operation for various types of radiation detectors.	K2A_W03 K2A_W04	Test	Lectures
The student has a knowledge of the production methods and practical applications of nuclear energy for power industry, the current state and perspectives of nuclear power in Poland and in the world. Student is aware of benefits and risks related to nuclear power for humans and the environment.	K2A_W04	Exam, test	Lectures
The student knows the methods of measurement and detection of nuclear radiation, radioactive contamination, knows methods of the exposure reduction and basic principles of radiation protection.	K2A_W03	Exam, test	Lectures
Student knows permissible doses of ionizing radiation, knows the applicable standards and legal regulations, and knows where to look for their novelizations.	K2A_W01	Exam, test	Lectures
Students use various teaching materials in Polish and English, provided by the teacher as well as found on their own. The student learns a critical approach to materials found on the internet.	K2A_U10	Exam, presentation	Lectures

ASSESSMENT CRITERIA:

Lecture:

The course credit is obtained by passing a final written test composed of tasks of varying degrees of difficulty.

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 2 h = 30 hours

- Preparation for obtaining a credit for the lecture (including the presentation preparation): 20 hours

- Attending lecturers' office hours: 2 hours

Total: 52 hours, 2 ECTS points.

Workload connected with lectures and classes requiring direct participation of the teacher amounts to 32 hours. This corresponds to 1 ECTS point.

RECOMMENDED READING:

[1] A. Z. Hrynkiewicz, ed., *Człowiek i promieniowanie jonizujące*, Wydawnictwo Naukowe PWN, Warszawa 2001.

[2] A. Hrynkiewicz, *Dawki i działanie biologiczne promieniowania jonizującego*, Państwowa Agencja Atomistyki, Instytut Fizyki Jądrowej, Warszawa-Kraków, 1993.

[3] P. Jaracz, *Promieniowanie jonizujące w środowisku człowieka*, Wyd. Uniwersytetu Warszawskiego, Warszawa 2001.

[4] K. N. Muchin, *Doświadczalna fizyka jądrowa*, t.1, 2, WNT, Warszawa 1978.

[5] B. Gostkowska, *Wielkości, jednostki i obliczenia stosowane w ochronie radiologicznej*, Centralne Laboratorium Ochrony Radiologicznej, wyd. III, Warszawa 2005.

[6] A. Skłodowska, B. Gostkowska, *Promieniowanie jonizujące a człowiek i środowisko*, Wyd. Nauk. SCHOLAR, Biuro Handlowe POLON, Warszawa 1994.

OPTIONAL READING:

[1] E. Skrzypczak, Z. Szefliński, *Wstęp do Fizyki jądra atomowego i cząstek elementarnych*, Wydawnictwo Naukowe PWN, Warszawa 2002.

[2] E. B. Podgorsak, *Radiation Physics for medical physicists*, Springer-Verlag, Berlin Heidelberg 2010.

PROGRAM PREPARATION:

Dr hab. Maria Przybylska, prof. UZ

FIELD THEORY

Course code: **13.2-WF-FizD-TePol**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Lecture	30	2	IV (FT)	Exam	
Class	30	2		Grade	

COURSE AIM:

The aim of the course is to familiarize students with the formalism of special and general theories of relativity, the similarities and differences between them, and their applications to the description of certain physical and astronomical phenomena.

ENTRY REQUIREMENTS:

Mathematical Analysis I and II, mathematical physics, algebraic and geometric methods in physics

COURSE CONTENTS:

- Spacetimes of Aristotle, Galileo, and Newton, the concept of the inertial system, absolute and relative character of the time and spatial distances between events, the geometry of the spacetime. Principles of relativity: Galileo's principle and Einstein's principle. Einstein's postulates.
- The Lorentz transformation, addition of velocities, constant velocity of light in various inertial frames, the time dilation and relativity of simultaneity, the contraction of distances.
- Space-time of the special theory of relativity: the event , the world line of a particle, thw cone of light , space-time interval , the classification of intervals, four vectors.
- Spacetime of general relativity , the relationship between spacetimes of general and special relativity , the local inertial frames.
- The principle of equivalence, relativity, minimal gravitational coupling and correspondence.
- Geodesic deviation and Einstein's equations in empty space. Newtonian limit of geodesic equations.
- Tensors of energy and momentum.
- Einstein's equations.
- The structure of Einstein's equations and their general properties.
- The Schwarzschild's solution.

TEACHING METHODS:

Conventional lecture with applications of trained formalism to some physical and astronomical systems and phenomena.

During class students solve exercises illustrating the content of the lecture.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student knows and understands the postulates of special and general theory of relativity. Students know and understand the theoretical results as well as experiments that led A. Einstein to his postulates	K2A_W01 K2A_U01	Exam, grade	Lectures, classes
The student knows the geometry of space-time of Aristotle, Newton, special and general theory of relativity. Students can explain differences between them	K2A_W02	Exam, discussion	Lectures, classes
The student can explain the phenomenon of time dilation and contraction of the distance from the point of view of both frames i.e. moving and resting coordinate frames	K2A_W05 K2A_U01	Exam, grade	Lectures, classes
The student knows and understands thought experiments with local and nonlocal lift and the relationship of this second experiment with Einstein's equations in empty space	K2A_W02 K2A_U01	Exam, grade	Lectures, classes
The student knows examples of energy and momentum tensor	K2A_U01	Exam, grade	Lectures, classes
The student knows the steps of reasoning leading to the formulation of Einstein's equations. Student know the properties of these equations and manners of their usage	K2A_W01 K2A_W02 K2A_U01	Exam, discussion	Lectures, classes
The student can explain the form of the Schwarzschild metric and knows geodesics in this metric	K2A_W02 K2A_U01	Exam, grade, discussion	Lectures, classes
The student knows the physical and astronomical phenomena confirming the validity of the special and general theory of relativity	K2A_W03	Exam	Lectures, classes
Student mastered the tensor calculus. They can calculate Christoffel symbols, curvature tensor, to determine equations of geodesics	K2A_W02	Exam, grade, calculations during classes	Lectures, classes
The students gain on their own the knowledge about the special and general theories of relativity and develop their skills using a variety of sources in both Polish and English, as well as using modern techniques (internet, various databases)	K2A_U10	Exam, grade	Lectures, classes

ASSESSMENT CRITERIA:

Lecture:

The course credit is obtained by passing a final written exam containing tasks of varying degrees of difficulty.

Class:

A student is required to obtain at least the lowest passing grade from the test organized during class.

To be admitted to the test from the content of lecture a student must receive a credit for the class.

Final grade: weighted average of grades from the class (40%) and the written texam from the content of lecture (60%).

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 2 hour = 30 hours

- Participation in class: 15 weeks x 2 hour = 30 hours
- Preparation for class including preparation for test: 15 hours
- Attending lecturers' office hours: 3 hours

- Preparation for the examination: 20 hours
- Examination: 2 hours

Total: 100 hours, 4 ECTS points.

Workload connected with lectures and classes requiring direct participation of the teacher amounts to 65 hours. This corresponds to 2.5 ECTS points.

RECOMMENDED READING:

[1] W. A. Ugarow, *Szczególna teoria względności*, PWN, Warszawa 1985.

[2] J. Foster, J. D. Nightingale, *Ogólna teoria wzgl*ędności, PWN, Warszawa 1985.

[3] J. B. Hartle, *Grawitacja, Wprowadzenie do ogólnej teorii względności Einsteina*, Wydawnictwo Uniwerystetu Warszawskiego, 2010.

[4] L. D. Landau, J. M Lifszyc, *Teoria pola*, Wydawnictwo Naukowe PWN, Warszawa 2009.

[5] R. D'Inverno, *Introducing Einstein's relativity*, Claredon Press, Oxford 1998.

[6] M. P. Hobson, G. Efstathiou, A. N. Lasenby, *General relativity: an introduction for physicists*, Cambridge University Press, Cambridge 2006.

OPTIONAL READING:

[1] B. F. Schutz, *Wstęp do ogólnej teorii względności*, Wydawnictwo Naukowe PWN, Warszawa 2002.

PROGRAM PREPARATION:

Dr hab. Maria Przybylska, prof. UZ

ELEMENTARY PARTICLE PHYSICS

Course code: **13.2-WF-FizD-FCzEl**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **The academic teacher giving the lecture**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					2
Lecture	30	2	IV (FT)	Grade	

COURSE AIM:

To acquaint students with the fundamental constituents of matter, their classification and outline the methods of a description of them and a description of their interactions.

ENTRY REQUIREMENTS:

Mathematical analysis, mathematical physics, theoretical and relativistic relativistic, foundations of quantum physics.

COURSE CONTENTS:

Lectures: *Historical development of particle physics - the classification of elementary particles. Symmetries. Models of elementary particles and their classification. Relativistic kinematics. Lagrange function in particle physics, fields, currents, symmetries and conservation laws.*

Classes: *Rozwiązywania zadań uzupełniających treści przekazywane na wykładzie. Solving complementary problems to the content provided in the lecture.*

TEACHING METHODS:

Conventional lectures and classes

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Acquire a general knowledge of the basics of particle physics. Skills in using literature and solving basic problems in particle physics. Understanding the need for learning throughout life.	K2A_W01 K2A_W06 K2A_U03 K2A_U08 K2A_U10 K2A_K01	Exam	Lecture

ASSESSMENT CRITERIA:

<u>LECTURE</u>: The test

STUDENT WORKLOAD:

- Participation in the lectures: 30 hours
- Participation in consultation: 2 hours
- Preparation for test: 20 hours

Total: 52 hours, 2 ECTS points.

RECOMMENDED READING:

[1] D. Griffiths, *Introduction to elementary particle physics*, Wiley 1987.

[2] G. Kane, *Modern elementary particle physics*, Adison- Wesley, 1993.

[3] F. Halzen, A. D. Martin, *Quarks and leptons: An introductory course in modern particle physics*, Wiley 1984.

[4] D. Perkins, *Wstęp do fizyki wysokich energii*, PWN, 2004.

OPTIONAL READING:

[1] J. Karaśkiewicz, *Elementy klasycznej I kwantowej teorii pola*, UMCS 2003.

PROGRAM PREPARATION:

Dr hab. Krzysztof Urbanowski, prof. UZ

ASTROPHYSICS OF COMPACT OBJECTS

Course code: **13.7-WF-FizD-AsObZ**
Type of course: **compulsory**
Director of studies: **The academic teacher giving the lecture**
Language of instruction: **Polish**
Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					6
Lecture	15	1	IV (AK)	Exam	
Class	30	2		Grade	

COURSE AIM:

Deep knowledge in the field of astrophysics of compacts objects

ENTRY REQUIREMENTS:

Basic knowledge of properties of compact objects, of quantum physics and of general relativity. Ability to program and use numerical methods

COURSE CONTENTS:

- Equation of state and structure of white dwarfs and neutron stars
- Non-rotating models of neutron stars
- Stability of neutron stars and white dwarfs
- Schwarzschild solution and properties of spherically symmetric black holes.
- Kerr black holes.
- Properties of rotating neutron stars
- Criteria for the stability of rigidly rotating relativistic stars
- Astrophysics of compact binaries
- Compact objects as sources of gravitational waves

TEACHING METHODS:

Lecture and class

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
A student is able to characterize the final stages of stellar evolution: white dwarfs, neutron stars and black holes. Can describe the basic differences between stars and compact objects. A student has	K2A_K01 K2A_K02 K2A_W03	exam, discussion	lecture

knowledge of equations of state of dense matter. Understands and describes the processes occurring in the interior of neutron stars and white dwarfs. A student is able to construct numerical models of non-rotating white dwarfs and neutron stars, and understands the reasons for the existence of the upper limit on their gravitational mass. Can describe the effect of rotation (rigid, differential) on the global parameters of neutron stars. Can provide the stability criteria for non-rotating and rotating relativistic stars. Can name and describe the most important relativistic effects associated with compact objects. Has knowledge of astrophysical phenomena occurring in binary systems containing a compact object. Has a basic knowledge of properties of black holes. Can describe mechanisms of emission of gravitational radiation from compact object binaries, or rotating neutron stars.	K2A_W04 K2A_W06 K2A_U01		
Students can write numerical codes (construct algorithms or adopt available numerical libraries) to solve basic problems arising in astrophysics of compact objects. In particular to integrate the equations of the stellar structure of relativistic stars (Oppenheimer-Volkoff equations) to obtain their gravitational mass and radius for a given equation of state. A student understands the need for further training and is able to understand the lectures of specialists in the field of relativistic astrophysics Can analyse astrophysical problems and formulate questions to have deeper understanding of a topic. A student is able to search for information in english literature.	K2A_W04 K2A_W05 K2A_U01 K2A_U02 K2A_U03 K2A_U05 K2A_U11 K2A_K01	current control, evaluation of the project, homework exercises, discussion, an oral presentation, passing a written test	class

ASSESSMENT CRITERIA:

Lecture: Positive passing of final exam

Class: Handing in homework exercises, oral presentations, passing a written test, a project - writing a program to calculate properties of compact objects. Positive marks of all activities.

Final grade: weighted average of the exam and class (50% and 50% respectively)

STUDENT WORKLOAD:

- Participation in lectures: 15 weeks x 1 hours = 15 hours

- Participation in class: 15 weeks x 2 hours = 30 hours

- Preparation to classes: 15 x 2 hours = 30 hours

- Homework exercises: 15 x 1 hours = 15 hours

- Preparation of the project: 15 x 1 hour = 15 hours

- Consultations, including the project discussion: 15 x 1 hour = 15 hours

- Preparation for the exam: 15 hours

- Participation in the exam: 3 hours

TOTAL: 138 hours, 6 ECTS.

Workload involving direct teacher participation: 63 hours corresponding to 3 ECTS

RECOMMENDED READING:

[1] S. Shapiro, S. Teukolsky, Black Holes, *White Dwarfs and Neutron Stars,* Wiley-VCH 2004.

[2] M. Demiański, *Astrofizyka relatywistyczna*, PWN.

[3] P. Haensel, A. Y. Potekhin, D. G. Yakovlev, *Neutron Stars*, Springer 2007.

[4] James B. Hartle, *Grawitacja*, 2009, ISBN 9788323504764.

OPTIONAL READING:

[1] C. W. Misner, K. S. Thorne, J. A. Wheeler, *Gravitation*, 1973.
[2] M. Camenzind, *Compact objects in astrophysics*, Springer, 2007.
[3] W. H. G. Lewin, M. van der Klis, *Compact Stellar X-ray Sources*, Cambridge Uni,   Press, 2006.

PROGRAM PREPARATION:

Dr hab. Dorota Rosińska, prof. UZ

GRADUATE SEMINAR II

Course code: **13.2-WF-FizD-Smgr2**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher directing the seminar**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Seminar	30	2	IV	Grade	

COURSE AIM:

To teach students how to prepare and show the presentation involving results discussed in MSc thesis. Preparation for writing MSc thesis.

ENTRY REQUIREMENTS:

Skills and knowledge gained during completed courses.

COURSE CONTENTS:

Elements of topics in the field of contemporary physics (with special emphasis on those discussed in students' MSc theses).

TEACHING METHODS:

Preparation of talks related to MSc thesis. Joint discussion concerning the merit and form of the presentations.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student gains a general knowledge in the field of current developments and latest discoveries in the physical sciences. He can adapt the his presentation to the level of recipient's knowledge, acquire by oneself his knowledge and to develop skills using a variety of sources (in Polish and foreign language) and modern technology. Student gains the ability to prepare oral presentations, in Polish and foreign language in the fields typical for both theoretical and experimental physics. He understands the role of active and passive dissemination of the knowledge	K2A_W06 K2A_U01 K2A_U10 K2A_U13 K2A_K02	Preparation and presentation at least two talks, student actgivity	Seminar

ASSESSMENT CRITERIA:

Preparation and presentation at least two talks related to the topis discussed in classes. Participation in discussions concerning presented talks.

STUDENT WORKLOAD:

- Participation in classes - 30 hours.
- Preparing presentations - 40 hours.
- Consultations – 10 hours.

Total: 90 hours, 4 ECTS.

Effort related to activities requiring direct participation of teachers 40 hours - equivalent to 2 ECTS.

RECOMMENDED READING:

[1] Articles recommended by lecturer, published in scientific and popular journals

[2] Scientific articles downloaded from the server: lanl.arxiv.org.

PROGRAM PREPARATION:

Dr hab. Krzysztof Urbanowski, prof. UZ

GENERAL SEMINAR

Course code: **13.2-WF-FizD-SPrze**

Type of course: **compulsory**

Language of instruction: **Polish**

Director of studies: **The academic teacher directing the seminar**

Name of lecturer: **Academic teacher from the Faculty of Physics and Astronomy**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Seminar	30	2	IV	Grade	

COURSE AIM:

To teach students how to prepare speeches and papers in the field of modern physics and how to prepare by oneself to refer their speeches.

ENTRY REQUIREMENTS:

Skills and knowledge gained during completed courses.

COURSE CONTENTS:

Elements of topics in the field of contemporary physics (with special emphasis of topics related to quantum optics and quantum information theory).

TEACHING METHODS:

Preparation of talks related to MSc thesis. Joint discussion concerning the merit and form of the presentations.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

The student gains a general knowledge in the field of current developments and latest discoveries in the physical sciences (**K2A_W06**). He/she can adapt the his/her presentation to the level of recipient's knowledge (**K2A_U01**), acquire by oneself his knowledge and to develop skills using a variety of sources (in Polish and foreign language) and modern technology (**K2A_U10**). The student gains the ability to prepare oral presentations, in Polish and foreign language in the fields typical for both theoretical and experimental physics (**K2A_U13**). He/she understands the role of active and passive dissemination of the knowledge (**K2A_K02**).

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
The student gains a general knowledge in the field of current developments and latest discoveries in the physical sciences.	K2A_W06	Preparation and presentation of talks. Active participation in discussions.	seminar
The student can adapt the his/her	K2A_U01	Preparation and presentation of	seminar

presentation to the level of recipient's knowledge.		talks. Active participation in discussions.	
The student can acquire by oneself his knowledge and to develop skills using a variety of sources (in Polish and foreign language) and modern technology.	K2A_U10	Preparation and presentation of talks.	seminar
The student gains the ability to prepare oral presentations, in Polish and foreign language in the fields typical for both theoretical and experimental physics.	K2A_U13	Preparation and presentation of talks.	seminar
The student understands the role of active and passive dissemination of the knowledge.	K2A_K02	Preparation and presentation of talks. Active participation in discussions.	seminar

ASSESSMENT CRITERIA:

Preparation and presentation at least two talks related to the topis discussed in classes. Active participation in discussions concerning presented talks.

STUDENT WORKLOAD:

- Participation in classes - 30 hours.
- Preparing presentations - 50 hours.
- Consultations - 5 hours.

Total: 85 hours, 4 ECTS.

Effort related to activities requiring direct participation of teachers 35 hours - equivalent to 1,5 ECTS.

RECOMMENDED READING:

[1] Articles recommended by lecturer, published in scientific and popular journals

[2] Scientific articles downloaded from the server: lanl.arxiv.org.

OPTIONAL READING: -

PROGRAM PREPARATION:

Dr hab. Wiesław Leoński, prof. UZ

MONOGRAPHIC LECTURE II – AN INTRODUCTION TO THE CLASSICAL AND QUANTUM FIELD THEORY

Course code: **13.2-WF-FizD-WyMo2**
Type of course: **compulsory**
Language of instruction: **Polish**
Director of studies: **dr hab. Anatol Nowicki, prof. UZ**
Name of lecturer: **dr hab. Anatol Nowicki, prof. UZ**

Form of instruction	Number of teaching hours per semester	Number of teaching hours per week	Semester	Form of receiving a credit for a course	Number of ECTS credits allocated
PHYSICS – second degree studies					4
Lecture	30	2	IV	Exam	

COURSE AIM:

Presentation of basic problems and ideas of classical and quantum field theory for students and their role in description of theory of elementary particles and their interactions.

ENTRY REQUIREMENTS:

Knowledge of Electrodynamics and Quantum Mechanics and elementary notions of functional analysis.

COURSE CONTENTS:

Classical field theory: cannonical formalism, canonical transformations and symmetry transformations. Noether Theorem. Scalar field, electromagnetic field and massive vector field. Fields interacting with electromagnetic field.

Quantum theory of free fields: quantum fields. Commutation relations for unequal times. Jordan-Pauli function. Notion of locality. Fourier representation of the field, the creation and annihilation operators. Normal product. The construction of the Fock Hilbert space.

Symmetry properties: translational and Lorentz covariance. Energy-momentum tensor. Noether theorem fo quantum fields.

Scalar field in interaction with an external sources: asymptotic space in description of interacting particles, scattering matrix S.

TEACHING METHODS:

Conventional lecture and work with original scientific papers.

LEARNING OUTCOMES AND LEARNING OUTCOMES VERIFICATION METHODS:

DESCRIPTION OF THE EFFECT	SYMBOLS OF EFFECTS	VERIFICATION METHODS	FORM OF CLASSES
Student is able to interpret known ealier experimental facts	K2A_W03 K2A_W04	Exam	Lecture

Student applies mathematical methods solving physical problems	K2A_W02	Exam	Lecture

ASSESSMENT CRITERIA:

Oral and written examination of the full range of material. Passing the exam for a passing grade.

STUDENT WORKLOAD:

- Participation in lectures: 30 h
- Preparing for exam: 40 h
- Work with original scientific papers: 30 h
- Consultations: 6 h
- Participation in the exam: 2 h

Total: 108 hours, 4 ECTS.

Effort associated with activities that require direct participation of teacher – 38hours, 2 ECTS.

RECOMMENDED READING:

[1] I. Białynicki-Birula, *Wstęp do teorii pól kwantowych*, PWN, Warszawa 1971.

[2] J. T. Łopuszański, *An Introduction to the Conventional Quantum Field Theory*, Wrocł. Univ. Press, 1976.

[3] Z. Jacyna-Onyszkiewicz, *Piętnaście wykładów z kwantowej teorii pola,* Wyd. Naukowe UAM, Poznań 2009.

OPTIONAL READING:

[1] J. T. Łopuszański, *An Introduction to Symmetry and Supersymmetry in Quantum Field Theory,* World Scientific Publ. Co. 1991.

[2] S. Weinberg, *Teoria pól kwantowych*, tom I, PWN, Warszawa 1999.

PROGRAM PREPARATION:

Dr hab. Anatol Nowicki, prof. UZ