CONTENT

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ ARE1a/99	**Course name:** Automation and Control of Physical Experiments

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 1.

Course level: II.

Prerequisities:

Conditions for course completion:
A student should manifest adequate knowledge regarding hardware and software related to the design and operation of automated systems used as experimental setups for performing physical experiments in Condensed matter physics, communication protocols and selected areas of digital signals processing. Sucessful passing of exam is necessary for obtaining credits. The number of credits is associated with the load for a student and is divided as follows: direct learning - 1 credit, study of the recommended literature - 1 credit, consultations and exam - 1 credit.
Obtaining 50 points in oral examination represents the treshold for sucesfull passing the exam.
Scale for evaluation is given as follows:
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
The student will learn on adequate level how to design automated setups for performing selected types of physical measurements in Condensed Matter Physics. He will become familiar with real properties of components of measuring and controlling subsystem. In addition, he will obtain skills in building experimental setup using standard communication protocols and will be able to program these experimental setups in Python.

Brief outline of the course:
1. Introduction to systems of automated measurements and control. Measuring and control subsystem. Enhancement of metrological properties of instrumentation by incorporating microcomputers. Sensors, basic characteristics, examples of technical realization of selected sensors.
2. Analog converters for acquisition of analog signal, analysis of selected types of converters. Analysis of the selected types of converters. Using operational amplifiers in the converters. Examples of operational networks.

3. Standard communication protocols for serial and paralel data transfer in experimental setups – RS 232, HPIB. Basic characterization. Synchronous and asynchronous regime for data transfer in serial mode. Detection of errors in serial mode. Hamming code. Structure of data bus in HPIB protocol. Selected system functions. Using handshake in transferring data. Interface and instrumentational messages.
4. Analog to digital converter (ADC), technical principle, examples for application. Direct converter, successive approximation technique, tracking method. Suppressing mains in integration converter.
5. Digital to analog converter (DAC), technical principle, examples for application. Converters with various resistance networks. Converter using voltage – time conversion. Differential and integral nonlinearity of DAC and ADC. Calculation and measuring differential and integral nonlinearity. Grain noise.
6. Digital filtering of data. Transmission function for analog and digital system. Laplace and Z-transformations. Methods for digital filter design. Design of the filter with infinite impulse response.
7. Analog and digital regulators. Properties of proportional, integral and derivative regulator. Program simulation of regulators operation.
Programming in Python:
Introduction to programming in Python using Pycharm editor, communication with measuring instruments. Types of variables, conversion of types. Functiones and methods. Working with data, basic data structures. Reading/writing data to files, numerical acquisition, graphical output. Basic types of program structures - sequence, cycle, conditional commands. Programming simple experimental setups.
8. Introduction to graphical programming in Python – type of variables, conversions among types, data operations.
9. Acquisition, creation, reading/storing data files in Python. Functions and methods.
10. Subroutines, using selected libraries.
11. Basic types of program structures – sequence, cycle, conditional commands.
12. Graphical output. Data transfer and communication among measuring units in Python.

Recommended literature:

J. Uffenbeck, Microcomputers and microprocessors, Prentice Hall, 1985.
P. Horowitz, W. Hill, The Art of Electronics, Cambridge University Press 1989.
S. Hack, Python Programming, Chopra International Consulting Ltd., 2021.

Course language:
slovak, english

Notes:
Presence form represents a standart form for the course, if a need arises, the course is performed using MS Teams.

Course assessment
Total number of assessed students: 60

A	B	C	D	E	FX
43.33	33.33	10.0	11.67	1.67	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 17.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ ARE1b/21/21	**Course name:** Automation and control of physical experiments

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 3 **Per study period:** 42
Course method: present

Number of ECTS credits: 4

Recommended semester/trimester of the course: 2.

Course level: II.

Prerequisities: ÚFV/ARE1a/99

Conditions for course completion:
For sucessfull passing the course a student is required to demonstrate adequate knowledge about real properties of automated setups used in Condensed matter Physics and programming skills for solution of selected problems in model automated setups. The course requires knowwledge of hardware used used in physical experiments in Condensed matter physics, selected methods of digital signals processing and standard communication protocols. These are acquired in lectures from course Automation of physical experiments. The number of credits reflects the time alocated for the exercises (3 hours) and the load for the student. which is divided as follows: direct learning - 2 credits, study of the literature and preparation of the programs for measurements - 1 credit, consultations and preparation of the reports - 1 credit.
Student receives score according to the level of his reports from each task. The treshold for sucessfull passing the course is 50 points from the following scale:
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
The student will obtain practical skills in programing automated experimental setups. Student will learn programming in Python language in the extent sufficient for programming selected experimental setups used in experimental studies of solids. He will become familiar with properties of real A-D and D-A converters and will be capable of creating programs for selected modes of operations in automated setups. In addition, he will obtain skills in programming automated setups for real-time data acquisition. He will learn selected methods for digital signal processing e. g. fast Fourier transform, phase-sensitive detection, he will become familiar with properties of analog and digital filters. He will obtain skills in designing various types of regulators and will become familiar with their real properties.

Brief outline of the course:
Programming in Python:

1.Introduction to PyCharm editor. Programming simple mathematical problems.
2. Selected numerical methods. Work with text strings, reading and writing data from (to) files.
3. Practical use of functions, methods and libraries.
4. Plotting figures, communication with measuring instruments.
Laboratory exercises:
5. Investigation of integral and differential nonlinearity of D-A and A-D converters.
6. A-D converter with feedback using successive approximation technique. Monitoring time dependence of voltage in discharging capacitor.
7. Digital temperature stabilizer. Study of accuracy, response time and stability of proportional regulator. Stabilizing temperature using integral regulator.
8. Fast Fourier transform. Influence of Shannon – Kotelnik sampling theorem on the frequency spectrum.
9. Transfer of analog signal in RC – elements. Determination of amplitude characteristics of selected RC – elements.
10. Digital filtering of signal I. Study of amplitude characteristics and impulse responses of selected digital filters of various types and orders. Work with library designed for digital signal filtering in Python.
11. Digital filtering of signal II. Design of a filter with infinite impulse response using method of maximal coincidence of the amplitude characteristics. Digital filtering of a signal in real time.
12. Digital lock – in amplifier. Study of phase – sensitive detector for various types of signals. Estimation of selectivity of lock – in amplifier.

Recommended literature:
Supporting material for each laboratory exercise is available.

Course language:
Slovak, English

Notes:
Presence form represents a standart form for the course, if a need arises, the course can be partially performed using MS Teams.

Course assessment
Total number of assessed students: 2

A	B	C	D	E	FX
50.0	50.0	0.0	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 17.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: KPPaPZ/KK/07	**Course name:** Communication and Cooperation
Course type, scope and the method: **Course type:** Practice **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course: 3.	
Course level: II.	
Prerequisities:	
Conditions for course completion: Evaluation: A condition for student evaluation is his active participation in the seminar. It is expected that the student will actively participate in the discussions and will express their positions and possible solutions. The output for evaluation will be the development of a project in the form of a Power Point presentation or a video on a selected communication topic.	
Learning outcomes: The goal of the subject Communication, cooperation is the formation and development of students' language and communication skills through experiential activities. The student can demonstrate an understanding of individual behavior in various communication contexts. The student can describe, explain and evaluate communication techniques (cooperation, assertiveness, empathy, negotiation, persuasion) in practical contexts. The student can apply these techniques in common communication schemes.	
Brief outline of the course: Communication Communication theory Non-verbal communication and its means Verbal communication (basic components of communication, language means of communication) about active listening Empathy Short conversation and effective communication (principles and principles of effective communication) Cooperation About the basics of cooperation About types, signs, types and factors of cooperation Characteristics of the team (positions in the team) Small social group (structure, development, characteristics of a small social group, position of the individual in the group)	

About leadership (characteristics of the leader, management, leadership styles)

Recommended literature:

Course language:

Notes:

Course assessment
Total number of assessed students: 281

abs	n	z
98.22	1.78	0.0

Provides: Mgr. Ondrej Kalina, PhD., Mgr. Lucia Barbierik, PhD.

Date of last modification: 31.07.2022

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ PSM/18	**Course name:** Computer simulations in magnetochemistry
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 1 / 2 **Per study period:** 14 / 28 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 2., 4.	
Course level: II.	
Prerequisities:	

Conditions for course completion:

To successfully complete the course, the student must demonstrate a sufficient understanding of the nature of magnetic properties in magnetic insulators. It is necessary to demonstrate software skills in simulating and analyzing experimental data during the solution of partial tasks. The condition for obtaining credits is the submission of the final project. The credit evaluation of the course takes into account the following student workload: direct teaching (1 credit), continuous assessment during the exercises (1 credit) and successful submission of the final evaluation project (1 credit). The minimum limit for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).

Learning outcomes:

Using various software packages, students will learn the procedures for the description and analysis of experimental data (heat capacity, susceptibility, magnetization, electron paramagnetic resonance). On the other hand, students will be able to simulate the magnetic properties of selected magnetic insulators from the structural properties of the material. For more effective problem management, we recommend passing the subjects Magnetochemistry (ÚFV/MAG/08) and Relaxation Processes in Molecular Magnets (ÚFV/RPM/14).

Brief outline of the course:

Topics no. 1.-6. taught by RNDr. V. Tkáč, PhD., topics no. 7.-12. taught by doc. RNDr. E. Čižmár, Ph.D.

1. Introduction to Matlab environment and simulation packages EasySpin (electron paramagnetic resonance and magnetic properties) and SpinW (magnetic properties and neutron scattering).
2. Definition of Hamiltonian of the studied magnetic system in the EasySpin package.
3. Introduction to point groups, anisotropy of the crystal field, magnetic correlations.
4. Simulation and analysis of magnetic properties of simple magnetic systems (heat capacity, susceptibility, magnetization, magnetocaloric phenomenon).
5. Magnetic relaxation, analysis of relaxation times, identification of relaxation processes.
6. Simulation and analysis of electron paramagnetic resonance data of powder sample and single crystal.
7. Introduction to the ORCA environment.

8. Brief introduction to DFT and Broken Symmetry (BS) DFT, optimization of molecular structure, calculation of exchange interaction.
9. Brief introduction to ab initio calculations of crystal field parameters from knowledge of magnetic substance structure, CAS, CASSCF, NEVPT2.
10. Calculation of electronic energy levels of ion from 3d group, work with active orbitals.
11. Calculation of optical and magnetic properties of an ion from the 3d group, determination of ligand field parameters.
12. Calculation of exchange interaction by CASSCF/NEVPT2 and BS-DFT method, comparison.

Recommended literature:

1. Molecular Symmetry, David J. Willock, 2009 John Wiley & Sons, Ltd.
2. Crystal Field Handbook, D. J. Newman, Betty Ng, 2007 Cambridge University Press,
3. Molecule-based Magnetic Materials: Theory, Techniques, and Applications, M. M. Turnbull, T. Sugimoto, L. K. Thompson, 1996, American Chemical Society,
4. Introduction to Molecular Magnetism, C. Benelli, D. Gatteschi 2015 Wiley-VCH Verlag GmbH & Co.KGaA
5. Dokumentácia balíka Easyspin http://easyspin.org/easyspin/documentation/
6. Dokumentácia balíka SpinW https://www.psi.ch/spinw/documentation
7. Dokumentácia balíka ORCA https://orcaforum.cec.mpg.de/
8. F. Neese, Introduction to Computational Chemistry, dostupne online
8. D. Aravena, M. Atanasov, V. G. Chilkuri, Y. Guo, J. Jung, D. Maganas, B. Mondal, I. Schapiro, K. Sivalingam, S. Ye, F. Neese, CASSCF Calculations in ORCA, a tutorial introduction, dostupne online

Course language:
Slovak, English

Notes:
Teaching is carried out in person or remotely using the MS Teams tool. The form of teaching is specified by the teacher, updated continuously.

Course assessment
Total number of assessed students: 4

A	B	C	D	E	FX
50.0	50.0	0.0	0.0	0.0	0.0

Provides: RNDr. Vladimír Tkáč, PhD., doc. RNDr. Erik Čižmár, PhD.

Date of last modification: 18.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ MSSFKL/15	**Course name:** Condensed Matter Physics
Course type, scope and the method: **Course type:** **Recommended course-load (hours):** **Per week: Per study period:** **Course method:** present	
Number of ECTS credits: 4	
Recommended semester/trimester of the course:	
Course level: II.	
Prerequisities: ÚFV/MKL/03 and ÚFV/MSA1/03 and ÚFV/FNT1/03 and ÚFV/TKL1/99	
Conditions for course completion: Obtaining required number of the credits given by the study plane.	
Learning outcomes: Evaluation of the competences of the students according to the profile.	

Brief outline of the course:

The state exam consists of defending diploma thesis and exam which has two blocks. The student is obliged to pass the exam from the compulsory block and one of two optional blocks.

I. Block – compulsory

Theory of condensed mater

1.1. Electrons in a periodic crystal potential. Bloch theorem. Born-van Kárman boundary conditions. Brillouin zone.

2. Mean electron velocity in a crystal. Effective mass. Density of states.
3. Approximation of nearly free electrons. Tight-binding method. Band structure.
4. Electrons in a magnetic field. Landau levels.
5. Lattice vibrations in harmonic approximation. Acoustic and optical modes in a linear chain with one and two atoms in a unit cell.
6. Lattice vibrations of three dimensional lattice. Phonons. Specific heat of crystals.
7. Optical properties of solids. Dielectric function. Optical conductivity.
8. Superconductivity and effect on physical properties of solids. Electron-phonon attractive interaction.
9. Cooper pairs. Ground state and excited state of a superconductor.
10. Itinerant and localized magnetism in solids. Magnons and spin waves in insulators.

II. Optional block

Magnetic properties of solids

1. Magnetic moment of atom.
2. Diamagnetism.
3. Paramagnetis.
4. Ferromagnetism.
5. Antiferromagnetism.
6. Ferrimagnetism.

7. Energy of ferromagnets.
8. Domain structure.
9. Magnetization processes.
Experimental methods
10. Measurement of intensity a induction of magnetic field.
11. Measurement of magnetostriction and anisotropy.
12. Types of electron microscopes, physical working principles and analytical uses.
13. Electron and X-ray diffraction. Comparison and utilization for study of solid state matter.
14. X-ray spectroscopic techniques EDS and WDS in electron microscopy.
III. Optional block
Low temperature physics
1. Superfluidity of 4He.
2. Superfluidity of 3He.
3. Properties of liquid solutions 3He - 4He.
4. Introduction to superconductivity – Josephson effect and its applications.
5. BCS a GLAG theories of superconductivity.
6. Transport of charge and heat at low temperatures.
7. Methods of reaching very low temperatures.
8. Methods of measurements of low temperatures.
Experimental methods
9. Specific heat at low temperatures - measurement techniques and data acquisition.
10. Low - level signal measurements.
11. Lock – in amplifier, principle of operation, examples of application.
12. Electron - paramagnetic resonance.
13. Construction elements of electron microscope, physical principle of operation, examples of application.

Recommended literature:
Recommended literature is specified in the corresponding information sheet of every subject which is part of the State exam.

Course language:
english

Notes:

Course assessment
Total number of assessed students: 26

A	B	C	D	E	FX
50.0	30.77	7.69	11.54	0.0	0.0

Provides:

Date of last modification: 21.12.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ DPO/14	**Course name:** Diploma Thesis and its Defence
Course type, scope and the method: **Course type:** **Recommended course-load (hours):** **Per week: Per study period:** **Course method:** present	
Number of ECTS credits: 16	
Recommended semester/trimester of the course:	
Course level: II.	
Prerequisities:	
Conditions for course completion:	
Learning outcomes:	
Brief outline of the course:	
Recommended literature:	
Course language:	
Notes:	
Course assessment Total number of assessed students: 71	

A	B	C	D	E	FX
70.42	19.72	5.63	1.41	2.82	0.0

Provides:	
Date of last modification: 07.12.2021	
Approved: prof. Ing. Martin Orendáč, DrSc.	

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ DDS/15	**Course name:** Domains and Domain Walls

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 2.

Course level: II., III.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient understanding of basic concepts of magnetism, anisotropy, statics and dynamics of domain structure. Knowledge of basic concepts is required. The student must be able to actively understand the content of the curriculum continuously during the semester, so that the acquired knowledge can be actively and creatively used in solving specific problems. The minimum limit for passing the exam is to obtain 51% of the total score, which takes into account all required activities with relevant weight.
Rating scale: A - 91% -100% points, B - 81% -90% points, C - 71% -80% points,
D - 61% -70% points, E - 51% -60% points.

Learning outcomes:
After completing the lectures and the final evaluation, the student will demonstrate adequate knowledge of the course standard, which is defined by the brief content of the course and the recommended literature. Theoretical knowledge of the content of the subject allows him to fully participate in the further study of specialized subjects that are related to the assignment of his dissertation. Can find connections between the domain structure of the investigated materials in relation to their crystallographic structure, the method of their preparation or their thermal or mechanical processing. The acquired knowledge will also facilitate the performance of the scientific part of the dissertation.

Brief outline of the course:
Time schedule of the subject contents is updated in electronic board in AiS2 sw. The subject content is focused in the following main topics:
1. The concept of domain structure
2. Experimental techniques for the study of domain structure
3. Examples of domain structures - their calculation
4. Material parameters determining domain structure, anisotropies
5. Domain walls - types, calculations
6. Experimental techniques for the study of statics and dynamics of domain walls
7. Statics of a domain wall - its potential, critical field
8.-9. Domain wall dynamics - basic models and parameters determining DS dynamics.
10. Domain wall dynamics in small magnetic fields - DS dynamics in adiabatic mode.

11. Dynamics of the domain wall in high magnetic fields - structure of the domain wall, its changes, interaction with phonons
12. Maximum speed of the domain wall - Schlomann and Walker limit
13. Spintronics - application of domain wall promotion in spintronics (Race-Track memory, Logic based on domains and domain walls, sensors), current problems and the future.

Recommended literature:
1. B.D. Cullity, C.D. Graham, „Introduction to magnetic materials", John Wiley & Sons, New Jersy (2009) 2. S. Chikazumi, Physics of Ferromagnetism, Oxford University Press, USA (2009) 3. S. Tumanski, Handbook of Magnetic Measurements, CRC Press (2011) 4. N. A. Spaldin, Magnetic Materials: Fundamentals and Device Applications, Cambridge University Press (2003)

Course language:
slovak, english

Notes:
Lectures can be done at presence form or online form using MS Teams. Education form is updated at the begining of the subject.

Course assessment
Total number of assessed students: 7

A	B	C	D	E	FX	N	P
71.43	0.0	28.57	0.0	0.0	0.0	0.0	0.0

Provides: prof. RNDr. Rastislav Varga, DrSc.

Date of last modification: 26.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ EM1/03	**Course name:** Experimental Methods in Condensed Matter Physics II
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 3.	
Course level: II.	
Prerequisities:	
Conditions for course completion: To successfully complete the course, the student must demonstrate sufficient understanding of the basic physical principles and technical details of state-of-the-art experimental methods used in Condensed Matter Physics and nanotechnology. To obtain credits, students are required to prepare a presentation about one of the described experimental methods, or its application and pass an oral examination. The credit evaluation of the course considers the following student workload: direct teaching (1 credit), self-learning and presentation preparation (1 credit), assessment (1 credit). The minimum threshold for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).	
Learning outcomes: The course provides a basic overview of the solid-state experimental methods and techniques studying the surface structures as well as the quasiparticle spectra.	
Brief outline of the course: Experimental methods focused on structural studies of solid-state surfaces, superconducting vortices, magnetic and electrical surface structures. Spectroscopies with high energy resolution for studies of electron and other quasiparticles in solids. 1. Introduction and historical overview of microscopy Optical microscopy, electron microscopy, scanning tunneling microscopy, atomic force microscopy. 2. Scanning tunneling microscopy (STM) Basic principles of STM, piezoelectric effect, methods of approaching the STM tip to the surface of the sample, controller electronics, scanning modes, principles of the PID feedback loop, topography imaging, effect of electronic structure on topography. 3. Atomic force microscopy (AFM) History: from STM to AFM, differences and common features, advantages and disadvantages, types of probes – surface interaction, scanning modes, tribology, force curves, imaging of organic nanostructures 4. Experimental methods	

Mechanical design; low temperature and high vacuum equipment; sample preparation: surface cleaning, preparation of thin films and nanostructures by evaporation, sputtering etc.; STM tip preparation: cold welding, electron bombardment, etching etc.
5. Examples of other Scanning probe microscopies (SPM)
Magnetic force microscopy, Kelvin probe microscopy, scanning Hall probe microscopy, spin polarized STM, Inelastic Electron Tunneling Spectroscopy, electrochemical STM etc. Lithography by SPM: dip pen, local anodic oxidation, nano scratching, nanoindentation etc.
6. Tunneling spectroscopy (TS)
Principles of quantum tunneling, tunneling through planar and vacuum barrier, electronic structure of metals, semiconductors and superconductors; Current vs. voltage and differential conductance vs. voltage characteristics, controller electronics, lock-in amplifier, conductance imaging tunneling spectroscopy (CITS), numerical methods of data analysis; TS of metals, semiconductors, molecules and various nanostructures.
7. TS of superconductors
Superconducting energy gap, tunneling contacts between normal metal and superconductor and between two superconductors, superconducting tip characterization, superconductivity in nanostructures, effect of temperature and magnetic field.
8. Superconducting vortices
Type I and II superconductors, interaction with magnetic field, imaging of vortices, vortex pinning, dynamics
9. Point contact spectroscopy (PCS)
Principles of PCS, from tunneling to point contact, hetero contacts, signal modulation techniques, fabrication of point contacts, effect of temperature and magnetic field.
10. PCS of superconductors
Andreev reflection, Josephson effect, Blonder – Tinkham – Klapwijk model, characterization of the superconducting order parameter
11. Visit of SPM and nanotechnology laboratory, experiment preparation and realization.
12. Visit of low temperature PCS and STM laboratory, experiment preparation and realization.

Recommended literature:
Kittel Ch.: Introduction to Solid State Physics, 7th edition, John Wiley and sons, NY, 1996
M. Tinkham: Introduction to Superconductivity, McGraw-Hill, Nwe York, 1996
Roland Wiesendanger: Scanning Probe Microscopy and Spectroscopy: Methods and Applications, Cambridge University Press 1994

Course language:
Slovak, English

Notes:
The course comprises onsite lectures. If necessary, online lectures will be provided via MS Teams.

Course assessment
Total number of assessed students: 71

A	B	C	D	E	FX
91.55	4.23	4.23	0.0	0.0	0.0

Provides: Mgr. Tomáš Samuely, PhD., univerzitný docent

Date of last modification: 27.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ EMT1/03	**Course name:** Experimental Methods in Solid State Physics I

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 1.

Course level: II.

Prerequisities:

Conditions for course completion:
A student should manifest adequate knowledge regarding experimental techniques adopted in experimental investigations of thermal, transport and dielectric properties of solids as well as study of basic characteristics of semiconductors. In addition, knowledge concerning realization of experiments under extreme conditions focusing on low level signal acqisition and processing is required. Sucessful passing of exam is necessary for obtaining credits. The number of credits is associated with the load for a student and is divided as follows: direct learning - 1 credit, study of the recommended literature - 1 credit, consultations and exam - 1 credit.
Obtaining 50 points in oral examination represents the treshold for sucesfull passing the exam.
Scale for evaluation is given as follows:
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
The course supports experimental skills of the students. More specifically, The student will learn advantages and shortcomings of selected experimental techniques adopted in experimental investigation of properties of solids. He will become familiar with physical phenomena used in the techniques. In addition, the student will learn how to approach experiments in which low-level signal measurements are necessary.

Brief outline of the course:
Following topics are addressed during semester, for each topic one lecture is anticipated:
1. Characterization of the course. Introduction to low-level signal measurements. Methods of suppressing noise depending on the frequency of the useful signal. Communication with controlling computer.
2. Grounding and shielding techniques in experimental setups. Active guarding. Ground loops. Using of isolation transformer.

3. Signal and noise bandwidth of filters. Method of phase sensitive detection. Lock-in amplifier. Principle of operation. Examples of application. Using lock-in amplifier for modulation of the measured signal.
4. Experimental methods for calorimetry. Contributions to specific heat. Adiabatic and relaxation techniques. Contactless magnetocalorimetry. Calorimetric determination of absorption of optical elements.
5. Experimental study of thermal conductivity. Contributions to thermal conductivity in solids. Measurements of boundary resistance between a thin conductive layer and substrate.
6. Investigation of dielectric properties of solids. Classification of measurement techniques according to excitation frequency.
7. Capacitor partially filled with dielectric. Properties of real capacitors from experimental setups. Measurements at low and medium frequencies. Bridge techniques.
8. Investigation of dielectric properties at high frequencies. Circuits with concentrated and distributed parameters.
9. Dielectric measurements at very high frequencies. Modes of electromagnetic field in cavity resonators and waveguides. Analysis of the results of dielectric measurements.
10. Characteristic properties of semiconductors. Determination of the magnitude of the energy gap, energies of donor and acceptor states, concentration of donors and acceptors.
11. Mobility of charge carriers in semiconductors. Experimental study of mobility of charge carriers. Deviations from Ohm law. Study of Hall effect in semiconductors and metals.
12. Experimental determination of Hall constant and electrical conductivity. Analysis of electrical resistivity in semiconductors. Thermoelectric effects in semiconductors. Determination of the temperature dependence of Fermi energy.

Recommended literature:
D. Gatteschi, R. Sessoli and J. Villain, Molecular Nanomagnets, Oxford University Press, 2006.
Scientific papers devoted to unconventional experimental techniques.

Course language:
slovak, english

Notes:
Presence form represents a standart form for the course, if a need arises, the course is performed using MS Teams.

Course assessment
Total number of assessed students: 60

A	B	C	D	E	FX
33.33	38.33	15.0	8.33	5.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 17.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice
Faculty: Faculty of Science

Course ID: ÚFV/ GPP/18	**Course name:** Graphic programming

Course type, scope and the method:
Course type: Lecture / Practice
Recommended course-load (hours):
Per week: 1 / 1 **Per study period:** 14 / 14
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course: 1., 3.

Course level: II.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient knowledge of solving practical problems in creating an automated experiment in the Labview environment, understand the basic concepts of graphical programming. The final evaluation consists of evaluation of individual work on three practical tasks in the Labview environment (emphasis is placed on algorithmic task management, sophistication of the proposed solution and the ability to defend the procedure and results of solutions in discussion with the teacher) and final test (40% evaluation of practical tasks + 60 % final test). The credit evaluation of the course takes into account the following student workload: direct teaching (1 credit), implementation of ongoing projects and evaluation by test (1 credit). Rating scale: A (90-100%), B (80-89%), C (70-79%), D (60-69%), E (50-59%), F (0-49%) .

Learning outcomes:
The aim of this course is to gain basic knowledge of programming in the graphical environment Labview, which is used in science, electronics and telecommunications in automated measurement and control of machines. The practical part will be devoted to work in Labview with special measuring technology and programmable microprocessors.

Brief outline of the course:
1. Basics of programming graphical programming tools Labview - user environment.
2. Principle of Virtual Machine.
3. The definition of the variables, using a local variable, the conversion of the types of variables.
4. Working with data - reading and writing files, numerical processing, graphical output.
5. Basic types of program structures - sequence, cycle, conditional cycle event invocation.
6. Sharing data between programs and computers.
7. Program setting properties of the user's environment.
8. Basic design of the structure of virtual instrument control experiment.
9. Programming simple automated reports, communications capabilities in measuring instruments.
Practical tasks:
10. Automation of measuring the characteristics of a simple low-pass filter using a lock-in amplifier
11. Communication with simple Arduino microprocessor (control of the stepper motor, read-out of analog signal from Hall sensor)

12. Generation of forced mechanical oscillations in the piezoelectric tuning fork using harmonic voltage pulse.

Recommended literature:

1. J. Vlach, J. Havlíček, M. Vlach, Začínáme s Labview, BEN, 2008
2. Learn LabVIEW, online tutoriál http://www.ni.com/academic/students/learn-labview/

Course language:

Slovak, English

Notes:

Teaching is carried out in person or remotely using the MS Teams tool. The form of teaching is specified by the teacher, updated continuously.

Course assessment

Total number of assessed students: 8

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: doc. RNDr. Erik Čižmár, PhD.

Date of last modification: 18.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ DEJ1/99	**Course name:** History of Physics
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course: 2., 4.	
Course level: I., II.	
Prerequisities:	
Conditions for course completion: Term project and its defense (60b), exam (40b). Credit evaluation of the subject: direct teaching and consultations (1credit), self-study, practical activities - project and evaluation (1credit). The minimum for completing the course is to obtain at least 51% of the total evaluation.	
Learning outcomes: Basic facts in the history of physics.	
Brief outline of the course: 1.-2. Evolution of knowledge before Galileo. 3.-4. Evolution of physics within the mechanical picture of the world. 5.-6. Evolution and limits of classical physics, phase of breakthrough in physics. 7.-8. Origin and evolution of the theory of relativity. Quantum physics and prospects of further evolution of physics and their application. 9.-10. Atomic and nuclear physics. 11.-12. Subnuclear physics. Contemporary state of physical research and its application in technology, natural sciences and philosophy. Position of physics in our society.	
Recommended literature: 1. R.Zajac, J.Chrapan: Dejiny fyziky, skriptá, MFF UK, Bratislava, 1982. 2. V.Malíšek: Co víte o dějinách fyziky, Horizont, Praha, 1986. 3. I.Kraus, Fyzika v kulturních dějinách Evropy, Starověk a středověk, Nakladatelství ČVUT, Praha, 2006. 4. A.I.Abramov: Istoria jadernoj fiziky, KomKniga, Moskva, 2006. 5. L.I.Ponomarev: Pod znakom kvanta, Fizmatlit, Moskva, 2006. 6. I.Kraus, Fyzika v kulturních dějinách Evropy, Od Leonarda ke Goethovi, Nakladatelství ČVUT, Praha, 2007. 7. I.Kraus, Fyzika od Thaléta k Newtonovi, Academia, Praha, 2007. 8. I.Štoll, Dějiny fyziky, Prometheus, Praha, 2009. 9. www-pages. 10.Brandt S., The harvest of a century, Discoveries of modern physics in 100 episodes, Oxford, 2009.	

Course language:
slovak and english

Notes:
The course is realized in the form of attendance, if necessary by distance learning in the environment of MS Teams or bbb.science.upjs.sk.

Course assessment
Total number of assessed students: 36

A	B	C	D	E	FX
83.33	8.33	8.33	0.0	0.0	0.0

Provides: doc. RNDr. Janka Vrláková, PhD.

Date of last modification: 19.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ KAK/14	**Course name:** Liquid crystals

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course: 1., 3.

Course level: II.

Prerequisities:

Conditions for course completion:
Direct teaching and self-study - 1 credit, Discussion accompanied with the preparation and presentation of a short project - 1 credit.

Learning outcomes:
Student will obtain basic information about structural, mechanical and optical properties of liquid crystals as well as about their applications in technical praxis.

Brief outline of the course:
Basic properties of liquid crystals. Classification of liquid crystals. Liquid crystalline phases and chemical structure. Optical anisotropy. Interaction of liquid crystals with electric and magnetic field – Freedericksz transitions. Applications. Composite systems based on liquid crystals.

Recommended literature:
1. P.G.de Gennes, The Physics of Liquid Crystals, Clarendon Press, Oxford 1974
2. N.Tomašovičová, P.Kopčanský, N.Éber: Magnetically Active Anisotropic Fluids Based on Liquid Crystals, Anisotropy Research: New Developments, ed. Hirpa Lemu, Nova Science Pub Incorporated, 2012.

Course language:
english

Notes:
The course is realized in the form of attendance, if necessary by distance.

Course assessment
Total number of assessed students: 5

A	B	C	D	E	FX
80.0	0.0	0.0	0.0	20.0	0.0

Provides: RNDr. Natália Tomašovičová, CSc.

Date of last modification: 22.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ FNT1/03	**Course name:** Low Temperature Physics

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 4 **Per study period:** 56
Course method: present

Number of ECTS credits: 6

Recommended semester/trimester of the course: 3.

Course level: II.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient understanding of the basics concepts, applications and applications in low temperature physics with emphasis on experimental examples. Knowledge of basic concepts about superfluidity, superconductivity, electrical and thermal conductivity, heat capacity of matter at low temperatures is required.
The credit evaluation of the course takes into account the following student workload: direct teaching (2 credits), self-study (2 credits) and assessment (2 credits). During the semester, the student must continuously master the content of the curriculum and pass two written tests. The final evaluation consists of the averaged results of two tests, each with a minimum success rate of 50%, evaluation scale: A (90-100%), B (80-89%), C (70-79%), D (60-69%), E (50-59%), F (0-49%).

Learning outcomes:
The cours gives knowledge of methods and techniques used in low-temperature physics and information on basic physical properties of condensed matter at low temperatures.

Brief outline of the course:
1. The concept of temperature. Thermodynamic absolute temperature. International Practical Scale ITS - 90. Overview of the properties of cryogenic liquids. Phase diagram of 4He. Thermal properties of 4He. Transport properties of 4He.
2. Superfluidity of 4He - Two-component theory, Bose condensation, Landau's theory of He-II, criterion of superfluidity. Thermodynamic functions of He-II. Wave propagation in helium. Quantum vortices. Motion of charged particles in He.
3. Properties of 3He - phase diagram of 3He. Manifestation of Fermi-Dirac statistics on the properties of liquid 3He. Landau's theory of Fermi fluid. Zero sound in Fermi fluid. Superfluid phases of 3He and their properties. Topology of superfluid phases 3He. Description of 3He superfluidity using an order parameter.
4. Properties of liquid solutions of 3He-4He. Elementary excitations in 3He-4He solutions. Properties of solid 4He. Properties of solid 3He. Phase transition in solid 3He. Solid solutions of 3He-4He. Quantum crystals. Quantum diffusion. Kapitza resistance.
5. Basic properties of superconductors, penetration depth, coherence length. Classification of superconductors.

6. Phenomenological theory of superconductivity and basics of BCS theory. High temperature superconductivity.
7. Tunneling phenomena in superconductors. Quantum interference and SQUID.
8. Electrical conductivity of metals at low temperatures. Classical and quantum size effects. Mesoscopic objects (Quantum Hall effect, ballistic transport, properties of 2D electron gas).
9. Heat capacity at low temperatures. Lattice and electron specific heat. Schottky's contribution. Heat capacity of superconductors and semiconductors. Thermal conductivity of metals. Electron and phonon component and their separation. Thermal conductivity of semiconductors, insulators and superconductors.
10. Methods of measuring low and very low temperatures. Gas thermometer. Condensation thermometers. Resistance thermometers. Thermocouples. Paramagnetic thermometers. Nuclear orientation thermometer. NMR thermometry. Noise thermometer.
11. 4He cryostats, 3He refrigerator. 3He-4He refrigerator. Pomeranchuk refrigerator. Adiabatic demagnetization of paramagnetic salts. Cryocoolers - pulsed-tube refrigerator.
12. Nuclear demagnetization. Hyperfine nuclear cooling. Nuclear magnetism in metals. Nanokelvin and negative temperatures.

Recommended literature:

Skrbek L. a kol.: Fyzika nízkych teplôt, Matfyzpress, MFF KU Praha, 2011.
C. Enss, S. Hucklinger, Low-Temperature Physics, Springer, 2005.
Jánoš Š.: Fyzika nízkych teplôt, ALFA Bratislava, 1980.
A. Kent: Experimental low-temperature physics. Mac Millan Press Ltd., 1993.
D.S. Betts: An introduction to Milikelvin Technology. Cambridge University Press, 1989.
P.V.E. McClintok et al.: Low-Temperature Physics. Blackie, Galsgow and London 1992.
F. Pöbell: Matter an Methods at Low Temperatures. Springer - Verlag, Berlin, 1992.

Course language:
slovak

Notes:
Teaching is carried out in person or remotely using the MS Teams tool. The form of teaching is specified by the teacher, updated continuously.

Course assessment
Total number of assessed students: 72

A	B	C	D	E	FX
86.11	8.33	5.56	0.0	0.0	0.0

Provides: doc. RNDr. Erik Čižmár, PhD.

Date of last modification: 18.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ MKL/03 | **Course name:** Magnetic Properties of Solids

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 4 **Per study period:** 56
Course method: present

Number of ECTS credits: 6

Recommended semester/trimester of the course: 2.

Course level: II., III.

Prerequisities:

Conditions for course completion:

To successfully complete the course (presence, if necessary distance) the student must demonstrate sufficient understanding of the concepts, phenomena and laws of magnetism of condensed matter, so that his knowledge of the physics of condensed matter is holistic. Knowledge of intrinsic magnetic properties of solids, types of energy, behavior of solids in a magnetic field and, in the case of ferromagnets and ferromagnets, also their domain structure is required. Knowledge of the basic use of magnetic materials in practice is also required.

Credit evaluation takes into account the scope of teaching (4 hours of lectures), evaluation (2 credits) and the fact that it is a profile subject that is part of the master's state exam. If the subject is included in the doctoral study of Progressive Materials, the fact that the subject is highly demanding for graduates of non-physical education is taken into account.

The minimum limit for successful completion of the course is to obtain 50 points in the oral exam from the subsequent point evaluation

Rating scale
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:

After completing the lectures and taking the exam, the student will have a deep knowledge of the magnetism of condensed matter and will have the ability to enter into a systematic theoretical and experimental solution of the problems of magnetism of condensed matter. He will also gain basic knowledge about the possibilities of using magnetic materials in technical practice.

Brief outline of the course:

1. week:
The classification of solids according to their magnetic properties. Classical diamagnetic, paramagnetic and ferromagnetic materials.
Magnetic quantities.

Magnetic moment. Orbital and spin momentum, orbital and spin magnetic moment.
2. week:
Atom with one electron and with more electrons. Hund's rules. Gyromagnetic experiments, resonance experiments.
The sources of magnetic fields (solenoid, toroid, Helmholtz coil, superconducting solenoid, electromagnet).
3. week:
The methods of measuring of the magnetic field. (Induction methods, fluxmeter method, magnetooptical effects, magnetoresistance, Hall effect, flux-gate method, SQUID method)
Diamagnetism. The classsical and Landau's diamagnetism. De Haas - van Alphen effect. Diamagnetism of superconductors.
4. week:
Paramagnetism.. The classical and quantum theory of paramagnetism. Pauli paramagnetism.
The methods of measuring the magnetic susceptibility of diamagnetics and paramagnetics. (Weiss method, torsion scales, Goy - Pascal scales).
5. week:
Ferromagnetism. Magnetization, Weiss theory of ferromagnetism. Exchange interactions. Curie temperature. Ferromagnetism of metals, alloys, rare earths and compounds.
6. week:
Thermal properties, thermal capacity, magnetocaloric effect and phase transitions.
Antiferromagnetism (structure, magnetization, susceptibility and Curie temperature).
7. week:
Ferrimagnetism (structure, spontaneous magnetization susceptibility to Curie and Neel temperature).
Study of spontaneous magnetic arrangement by neutron diffraction.
8. week:
Temperature dependence of spontaneous magnetic polarization, determination of Curie temperature (Extrapolation methods, line method of equal polarization, measurement of thermodynamic coefficients).
Energy of ferromagnets energy. (exchange, crystallographic magnetic anisotropy, magnetostriction, magnetoelastic, magnetostatic)
9. week:
Magnetic anisotropy.
Methods for measuring anisotropy constants (by measuring magnetization work, torsional anisometer).
Electrical resistance, Hall effect and magnetoresistance of ferromagnets.
10. week:
Domain structure of ferromagnets. Geometry and energy of domain walls. Primary and secondary domain structure.
Methods of domain structure monitoring (powder pattern method, magneto-optical phenomena, electron microscopy, X-ray method, ferromagnetic probe method).
11. week:
Magnetostriction, Villary effect.
Spontaneous magnetostriction. Magnetostriction of a monodomain particle, single crystals and polycrystalline substances.
Methods of measuring magnetostriction constants (strain gauge measurement, mechanical - optical, interference methods).
12. week:
Magnetization curves.

Demagnetizing effect of the sample. Magnetic circuit, yoke.
Basic ideas for the magnetization process. Elementary magnetization processes. Barkhausen phenomenon.
Methods for investigating the Barkhausen effect.
Mechanism of magnetic reversal, magnetic hysteresis, remanence and coercivity.
13. week:
Methods of recording the primary magnetization curve and the hysteresis loop (static and dynamic).
Premagnetization losses and methods of their measurement (wattmer, phase shift method, calorimetric, hysteresis loop area measurement).
Types of susceptibility of ferromagnetic substances (initial, maximum, reversible, irreversible, differential).
Measurement of susceptibility of ferromagnetic substances (Maxwell - Wien bridge, Owen bridge).

Recommended literature:

1. S. Chikazumi: Physics of Magnetism, J.Willey and Sons, Inc. New York, London, Sydney, 1997.
2. J. M. D. Coey: Magnetism and Magnetic Materials, Cambridge University Press, 2009
3. H. Kronmüller, S. Parkin - Handbook of Magnetism and Advanced Magnetic Materials, Wiley 2007
4. F. Fiorillo, Measurement and Characterization of Magnetic Materials, _Elsevier 2004
5. S. Tumanski, Handbook of Magnetic Measurements, CRC Press, 2011

Course language:
english

Notes:
Presence form represents a standart form for the course, if a need arises, the course is performed using MS Teams.

Course assessment
Total number of assessed students: 125

A	B	C	D	E	FX	N	P
38.4	14.4	9.6	2.4	2.4	4.0	2.4	26.4

Provides: prof. RNDr. Peter Kollár, DrSc.

Date of last modification: 22.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ MAG/08/08	**Course name:** Magnetochemistry

Course type, scope and the method:
Course type: Lecture / Practice
Recommended course-load (hours):
Per week: 2 / 1 **Per study period:** 28 / 14
Course method: distance, present

Number of ECTS credits: 5

Recommended semester/trimester of the course: 1.

Course level: II., III.

Prerequisities:

Conditions for course completion:

Continuous active acquisition of the subject is required during the course of Magnetochemistry, which is necessary for independent mastery of individual tasks in self-study and in solving specific homework assignments. During the semester, the student will get a theoretical project based on the study of foreign journal literature (understanding of a specific scientific article and based on it the elaboration and presentation). Another condition for completing the course is active participation in lectures and seminars. In the exercises, the student will get a concrete idea of how the experimental data are analyzed. Subsequently, the student independently analyzes the experimental data of the selected magnetic compound in the frame of two to three home projects and presents the results of the analysis at a joint meeting. Another condition for obtaining credits is successful completion of the exam from the theoretical part in the form of an extensive oral discussion, where the student demonstrates understanding of basic concepts and relationships between them, finding connections and understanding the course as a coherent whole logically built on the basis of gradual incorporation of individual interactions. The minimum threshold for passing the course is successful completion of self-study projects and individual assignments during the semester and mastering the final oral exam by more than 50 percent.

Credit evaluation takes into account the scope of direct teaching (2 credits), self-study of recommended literature and preparation of presentation (1 credit) elaboration of home assignments (1 credit), consultations and evaluation (1 credit)

Learning outcomes:

After completing the course, the students will gain a basic perspective, which will allow them to sufficiently orient themselves in the current scientific literature focused on quantum magnetism. Based on the acquired theoretical knowledge and practical experience, they will be able to independently study magneto-structural correlations in electrically non-conductive materials and identify their magnetic state, which is important especially for quantum technologies but also for practical applications such as magnetic cooling especially at low temperatures. Based on the acquired knowledge, discussions and the creation of individual projects, they will also learn the basics of critical thinking in this field.

Brief outline of the course:

1. Development of theories of the structure of atom. Bohr model of atom. Electron in the hydrogen atom. Wave functions and orbitals. Quantum numbers. Magnetomechanical parallelism. Spin of electron. Atoms with higher number of electrons. Electron-electron interactions. Ground state of atom. Hund's rules. Terms. Multiplets.
2. Atom in magnetic field: I. Magnetic properties of atom. Paramagnet. Macroscopic properties of paramagnetic materials. Specific heat – Schottky maximum, experimental techniques of heat capacity measurements. Magnetization - Brillouin function, experimental techniques of magnetization measurements.
3. Atom in magnetic field II: Magnetic susceptibility – Curie law, experimental techniques of susceptibility measurements. Electron paramagnetic resonance. Field induced magnetic moment of filled electronic shells. Diamagnetic susceptibility. Pascal's constants.
4. Atom in crystal field. Weak, medium, strong crystal field. Medium crystal field: Ions with one electron in the unfilled subshell, ions with two and more electrons in the unfilled subshell. Freezing of angular momentum. Jahn-Teller effect.
5. Spin-orbit coupling in the first and second order of perturbation theory. Spin Hamiltonian. Spin Hamiltonian for tetragonal symmetry of the medium crystal field. Kramers theorem. Thermodynamics of the system of paramagnetic ions in crystal field. Specific heat. Magnetization. Magnetic susceptibility. Electron paramagnetic resonance of the systems with crystal field.
6. Magnetic correlations. Exchange coupling. Molecule of hydrogen. Heisenberg Hamiltonian. Exchange pathway. Direct and undirect exchange interaction. Anderson model of superexchange. Goodenough-Kanamori empirical rules.
7. Spatial arrangement of exchange pathways. Cluster. Chain. Layer. Low-dimensional magnetic systems.Three-dimensional magnetic systems. Phase transitions. Correlation length. Ehrenfest's theorems. Long range order. Short-range order. Magnetic dimer: Specific heat. Magnetization. Magnetic susceptibility. Electron paramagnetic resonance.
8. Anisotropy in the exchange interactions. Sources of anisotropy. Dipolar interaction. Heisenberg model. Ising model. XY model.
9. Analysis of the structure of selected compounds based on Ni(II) and Cu(II) ions. Determination of exchange pathways and the influence of crystal field. Suggestion of appropriate magnetic models for the compounds. Using scientific software Origin each student will perform analysis of experimental data of temperature dependence of specific heat of Ni(II) compound, i.e. separation of lattice contribution, calculation of magnetic entropy, comparison with expected theoretical values.
10. Application of theoretical prediction of chosen model for magnetic specific heat of Ni(II) compound and considering the correctness of the model, explanation origin of deviations of experimental data from the applied model .
11. Analysis of magnetic susceptibility of Ni(II) compound-subtraction of diamagnetic contribution, calculation of magnetic moment and g-factor. Application of Curie-Weiss law, then fitting exp. data by a model prediction yielding g-factor and strength of crystal field.
12. Comparison of results obtained from the analysis of specific heat and susceptibility. Then magnetization is calculated and compared with experimental data. Students will make hypothesis about the ground state of the system and they will suggest new experiments on the studied compound.
13. Comparison of the results obtained by individual students which provides information about the influence of individual approach, as number of particular analyses, which test robustness of obtained material parameters etc. Monitoring and examination of elaboration of analogic home projects on Cu(II) compound, accompanied with consultations.

Recommended literature:

1.R.L. Carlin, A.J. Duyneveldt: Magnetic properties of transition metal compounds. New York, inc. Springer Verlag, 1977.

2. J-P. Launay, M. Verdaguer, Electrons in Molecules, Oxford 2018.
3. A. Abragam, B. Bleaney, Electron Paramagnetic Resonance of Transition Ions, Oxford, 2012.

Course language:
english

Notes:
The course Magnetochemistry is realized in the attendance form. In some special cases (as was pandemics of Covid) the teaching is realized online using software MS Teams, which enables to keep the contact with students and to keep the level and quality of the course.

Course assessment
Total number of assessed students: 29

A	B	C	D	E	FX	N	P
48.28	13.79	24.14	3.45	3.45	0.0	0.0	6.9

Provides: doc. RNDr. Alžbeta Orendáčová, DrSc.

Date of last modification: 27.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ MOP/14	**Course name:** Magnetooptics
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 3.	
Course level: II.	
Prerequisities:	
Conditions for course completion: To successfully complete the course, the student must understand the basics of magneto-optical Kerr phenomenon (MOKE), its use and techniques of its measurement. He must know the mathematical apparatus of Jones formalism, by which he should be able to quantify first-order magneto-optical phenomena in various configurations of MOKE. The final assessment is done after an oral exam, which contains several questions. Final assessment takes into account the scope of teaching (2 credits), consultations and assessment (1 credit). Grading scale: A - 91%-100% points, B - 81%-90% points, C - 71%-80% points ,D - 61%-70% points, E - 51%-60% points.	
Learning outcomes: After completing the lectures, the student will have knowledge of the use of magneto-optical Kerr phenomenon (MOKE) in the study of modern magnetic materials. The mathematical apparatus of Jones formalism allows him to quantify the contrast intensity of first-order magneto-optical phenomena in various MOKE configurations, as well as to optimize the setting of individual optical elements. In addition to describing the origin of these phenomena, the student will also be familiar with MOKE measurement techniques. These include, for example, laser based MOKE, as well as MOKE imaging by an optical microscope running in static and time-resolved regime.	
Brief outline of the course: 1. Polarisation of a light. Reflection of a light at the interface between two non- magnetic media. Fresnel coefficients of reflection and transmission. History of magneto-optics: a brief overview on the developments of magneto-optical effect and related techniques since the first discovery by M. Faraday in 1845. 2. Modern magneto-optics: basics and fundamentals of magneto-optics theory in terms of optics and quantum mechanics. Classical treatment of the magneto-optic Kerr effect (MOKE) and magneto-optic Faraday effect (MOFE) based on the Lorentz force for electrons in motion by electric field of the light under effective magnetic fields inside magnetic materials. Exact description of magneto-optic effect based on quantum mechanics. Perturbative handling of quantum mechanical description leading to the off-diagonal elements in dielectric tensor, which one can utilize practically to handle	

magneto-optic effects. Magneto-optical Fresnel coefficients involved with reflection/transmission linked to the magneto-optic effects. Jones formalism of reflection and transmission coefficients.
3. Magneto-optical Kerr/Faraday effect measurement techniques: extensive overview on various MOKE/MOFE experimental setup and technical details. Light sources based on arc discharge such as Hg/Xe lamp with peculiar wavelength peaks, where spectral response of MOKE/MOFE could also give us an important material information. Kerr/Faraday spectrometer and Kerr/Faraday ellipsometry technique. Various laser light sources with/without temporal coherency as a powerful in exploring magnetic properties of target magnetic materials. Conventional laser and laser diodes as light source. Magneto-optic effect in X-ray wavelength. Numerous solutions depending on various research goals is introduced with optimization of optical path and optical components. Available photodetectors ranging from affordable Si-detector to photomultiplier with different specifications. Lock-in techniques with several modulation techniques used in MOKE/MOFE measurements.
4. Second-order magneto-optic effect: The second-order magneto-optic effects from the experimental point of view with particular focus on applications for antiferromagnetic materials. Transverse MOKE/MOFE is the second-order magneto-optic effect. Several solutions for experimental measurement of the second-order magneto-optic effects are introduced.
5. Imaging based on magneto-optical techniques: Optics-based MOKE/MOFE techniques are best equipped when combined with imaging techniques. MOKE/MOFE imaging based on a polarizing optical microscope with integration of electromagnets. Various possible setups from a standard normal incidence/reflection microscope to oblique-incidence ones. Selection of CCD devices with various specifications. Application of lock-in technique for scanning MOKE/MOFE imaging. Parasitic Faraday effect in objective lens from large magnetic field. Examples of cryostat technique for low-temperature imaging and practical conditions.
6. Ultrafast spin dynamics study based on magneto-optical techniques: MOKE/MOFE as a major experimental tool to explore ultrafast spin dynamics behaviour. Pump-probe stroboscopic technique using femtosecond laser, which can be extended to atto- and picosecond timescales. Experimental details of laser, oscillator, pulse-picking, synchronization are discussed, together with fundamentals of magneto-optic stroboscopic measurements.
7. Optical control of spin state: application of MOKE technique for exploring the newly discovered all-optical spin switching phenomena based on a spin-orbit interaction as a fundamental mechanism. Magnetization reversal by the light without need of external field or spin-polarized current. All-optical control of spin state. The inverse-Faraday effect. All-optical switching behaviours followed by introduction of relevant magneto-optic setup details.
8. Future of magneto-optics: Concluding remarks with introducing recent trends of MOKE/MOFE techniques and applications.

Recommended literature:

1. Zvezdin AK, Kotov VA, Modern magnetooptics and magnetooptical materials, Taylor & Francis (1997).
2. S. Visnovsky, Optics in Magnetic Multilayers and Nanostructures, CRC Press (2006).
3. A. Hubert, R. Schafer, Magnetic domains, Springer (1998).
4. Sugano S., Kojima N., Magneto-optics, Springer (1999).
5. V. V. Eremenko, Magneto-optics and spectroscopy of antiferromagnets, Springer-Verlag (1992).
6. Philip E. Wigen, A UV Magneto-Optic Kerr (MOKE) Microscope, Ohio State University Department of Physics (1997).

Course language:
Slovak, English

Notes:

The course is realized via on-site lectures, if necessary, online via MS Teams.

Course assessment
Total number of assessed students: 3

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: RNDr. Kornel Richter, PhD.

Date of last modification: 28.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: KF/ FMPV/22	**Course name:** Methodology of Science 1
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 1 / 1 **Per study period:** 14 / 14 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course:	
Course level: II.	
Prerequisities:	
Conditions for course completion: Attendance: A student may have one unexcused absence in seminar at the most. Absence in more than one seminar must be reasoned and substituted by consultations. Conditions of continuous and final control: during the semester a student is continuously checked and assessed according to his/her activity. To be awarded the credits, a student must pass a test from knowledge obtained in the lectures and seminars. Results of the test will make up the final grade.	
Learning outcomes: The course is aimed at getting familiar with the basic issues of methodology and philosophy of science. Significant part will be devoted to presenting the main concepts of the philosophy of science in the 20th century and this aim will be achieved by reading the source and interpretive texts.	
Brief outline of the course: • Falsificationism and critical realism by K. R. Popper. • Development and critique of the Popper's concept. • Understanding the science development in the work by T. S. Kuhn. • Methodology of scientific research programmes of I. Lakatos. • Methodological anarchism of P. Feyerabend. • W.V.O. Quine – the issue of relation between theory and empiricism.	
Recommended literature: BILASOVÁ, V. – ANDREANSKÝ, E.: Epistemológia a metodológia vedy. Prešov: FF PU 2007. FAJKUS, B.: Filosofie a metodologie vědy. Praha: Academia 2005. BEDNÁRIKOVÁ, M. Úvod do metodológie vied. Trnavská univerzita: Trnava 2013. DÉMUTH, A. Filozofické aspekty dejín vedy. Trnavská univerzita: Trnava 2013. FEYERABEND, P.: Proti metodě. Prel. J. Fiala. Praha: Aurora 2001. KUHN, T. S.: Štruktúra vedeckých revolúcií. Prel. Ľ. Valentová. Bratislava 1982.	
Course language: Slovak	
Notes:	

Course assessment
Total number of assessed students: 6

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: prof. PhDr. Eugen Andreanský, PhD.

Date of last modification: 01.02.2022

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ MSA1/03	**Course name:** Methods of Structural Analysis

Course type, scope and the method:
Course type: Lecture / Practice
Recommended course-load (hours):
Per week: 3 / 2 **Per study period:** 42 / 28
Course method: present

Number of ECTS credits: 7

Recommended semester/trimester of the course: 2.

Course level: I., II., III.

Prerequisities:

Conditions for course completion:
For successful completing of the subject student has to show after taking exam adequate knowledge from the area using sophisticated research infrastructure for structural analysis of solids. Content of the subject is focused study of structure analytical methods as TEM, SEM, STEM and X-ray techniques. Credits evaluation takes into account taking part at the lectures - 3credits, study of recommended literature -1credit, working out of experimental protocol from OM and EM -2 crediddts and study of recommended literature -2 credits, 2 credits – project, 1 credit – study for 2 written tests (EM and X-ray) - 1 credit. Minimal value to obtain evaluation for is reach 50% of each evaluation (tests and project) points. Point ratio protocol/test EM/TEST X-ray is 40/30/30.

Learning outcomes:
Student due to lecrures and experimental work after final exam demonstrates that he/she meets expectations according to the standards of the subject, which is predicted by short content andreferences. Student is able to use modern methods for structural analysis of metals. He has experiences with optic microscopy, electron microscopy (TEM, SEM, STEM),electron microprobe analysis and X-ray diffractometry.

Brief outline of the course:
Optic microscopy. Electron microscopy: Electron beam instruments, Electron optics, Electron lences and deflection systems, Transmission electron microscopy - principle and construction. Electron – specimen interactions. Electron diffraction. Kikuchy lines. Scanning electron microscopy – principle and cnstrucion. Scanning transmission electron microscopy. High Voltage electron microscopy. Electron microprobe analysis: WDX spectrometer, EDX spectrometer, Auger electron spectrometer. Self-emision microscopy. Convergent beam diffraction.
X-ray diffractometry: Scattering of x-rays, Neutrons and neutron scattering, CW - diffractometer, Ewald´s sphere, Diffraction on powder samples, The main characteristics of powder diffraction pattern, Structure factor, Ocupation factor, Atomic displacement factor, Peak intensity, shape and symmetry, Sherrer equation. Peak profile, Rietweld method. Qualitative phase analysis, parameters of elementary cell, Profile analysis of diffraction peak and interpretation of profile analysis.

Recommended literature:
1. P.W. Hawkes, J.C.H. Spence, Science of Microscopy, Springer, 2007, ISBN: 10:0-387-25296-7.

2. Vitalij Pecharsky, Peter Zavalij, Fundamentals of Powder Diffraction and Structural characterization of Materials, Publisher: Springer (March 3, 2005)
ISBN-10: 0387241477, ISBN-13: 978-0387241470
3. Jens Als-Nielsen, Des McMorrow, Elements of Modern X-ray Physics, Publisher: Wiley; 2 edition (April 4, 2011),ISBN-10: 0470973943, ISBN-13: 978-0470973943.
4. Current Publications in the field of TEM, REM, X-ray
5. M.D. Graef, M.E. Henry, Structure of Materials, Cambridge Univ. Press, 2012, ISBN:978-1-107-00587-7.
6. S. Amelinckx, D. Dyck, et al, Electron Microscopy - Principle and Fundamentals, VCH, 1997, ISBN: 3-527-29479-1.

Course language:
1. English

Notes:
Lectures can be done at presence form or online using MS Teams. Education form is updated at the begining of the subject. All ppt presentations are accesible in LMS UPJŠ.

Course assessment
Total number of assessed students: 93

A	B	C	D	E	FX	N	P
38.71	21.51	7.53	1.08	0.0	0.0	0.0	31.18

Provides: prof. RNDr. Pavol Sovák, CSc., doc. Ing. Karel Saksl, DrSc., Ing. Vladimír Girman, PhD., Mgr. Maksym Lisnichuk, PhD.

Date of last modification: 21.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ MPN/14	**Course name:** Methods of preparation and characterization of nanostructures

Course type, scope and the method:
Course type: Lecture / Practice
Recommended course-load (hours):
Per week: 2 / 1 **Per study period:** 28 / 14
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 2.

Course level: II.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate a sufficient understanding of the basic techniques designed for the preparation and characterization of nanostructures. The credit evaluation of the course takes into account the following student workload: direct teaching 1 credits, laboratory practice 1 credit, continuous study for the test and final exam 1 credit. The condition for obtaining credits is presence at laboratory exercise, and passing an oral exam, which consists of a selected topic. The minimum threshold for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60-69%), E (50-59%), F (0-49%).

Learning outcomes:
The aim of the course is to make an overview of technologies for the preparation and characterization of nanostructures and nanodevices. The course focuses on the preparation of microelectromechanical devices and microanalytical devices and nanoobjects using mainly the so-called top down methodologies. The student will gain knowledge about the forces that affect nanoobjects and interactions between them.The main emphasis will be on conventional lithographic preparation techniques and shaping of nanostructures, methods of characterization of thin films, nanoparticles and nanomaterials. Unconventional lithographic methods will also be discussed. Last but not least, the student will also get acquainted with applications of nanostructures in research focused on nanophysics, nanocatalysis and nanoelectronics. Part of the course is also a practical laboratory exercise, in which the student gets acquainted with the devices used in practice for the preparation and characterization of thin films and top-down technologies used for the preparation of nanostructures.

Brief outline of the course:
1. Introduction.
2. Energy on nanoscale.
3. Methods of nanostructure fabrication general introduction.
4. Thin film preparation.
5. Nanofabrication.
6. Characterization of thin films, nanostructures and nanodevices.
7. Atomic force mictroscopy and scanning tunneling microscopy.

8. Unconventional nanopatterning methods. I
9. Unconventional nanopatterning methods. II
10. Unconventional nanopatterning methods. III
11. Fabrication of microelectromechanical and nanoelectromechanical systems (MEMS, NEMS).
12. Applications of nanostructures and nanodevices.

Recommended literature:

1. B. Bhushan Ed., Handbook of nanotechnology, Springer Academic Publishers, 2nd edition, 2007.
2. J. A. Rogers, H. H. Lee, Unconventional nanopatterning techniques and applications, Wiley, 1990.
3. G. Hornyak, J. Dutta, H. F. Tibbals, A. K. Rao, Introduction to nanocience CRC Press, 2008.
4. G. A. Ozin, A. C. Arsenault, L. Cademartiri, Nanochemistry A Chemical Approach to Nanomaterials, RSC Publishing, 2005.

Course language:
Slovak, English

Notes:
Teaching is carried out full-time or part-time using the MS teams platform. Form of teaching are specified by the teacher at the beginning of the semester and continuously updated as needed.

Course assessment
Total number of assessed students: 59

A	B	C	D	E	FX	N	P
50.85	13.56	5.08	0.0	0.0	0.0	0.0	30.51

Provides: Mgr. Vladimír Komanický, PhD., univerzitný docent

Date of last modification: 27.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ NANO/09	**Course name:** Nanomaterials and Nanotechnologies
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 2 / 1 **Per study period:** 28 / 14 **Course method:** present	
Number of ECTS credits: 4	
Recommended semester/trimester of the course: 2.	
Course level: II., III.	
Prerequisities:	
Conditions for course completion: To successfully complete the course, the student must demonstrate sufficient knowledge of foundations of nanomaterials and nanotechnologies. The credit evaluation of the course takes into account the following student workload: 1 credits: direct teaching and self-study of recommended supplementary literature, 3 credits: successful completion of an exam, which consists of a written test and a presentation on a selected topic in the field of nanomaterials.	
Learning outcomes: After completing lectures and exercises, the student will gain a comprehensive view of the properties of nanomaterials and their wide application. The result of education is: a) Complementing and summarizing knowledge in the field of distribution of nanomaterials and nanotechnologies. b) Overview of methods for characterization of modern materials. suitable for practical applications. c) Creation of the necessary terminological and knowledge base for mastering related subjects.	
Brief outline of the course: The course will provide information on nanomaterials in a clear and illustrative way in the following structure Week 1: Definition, history, present and future of nanotechnologies. Basic concepts and metrology in nanotechnologies. Week 2: Nanomaterials in 1D dimensions: thin films, thin films and surfaces; nanomaterials in 2D dimensions: carbon nanotubes, inorganic nanotubes, nanowires, biopolymers, nanomaterials in 3D dimensions: nanoparticles, fullerenes, dendrimers, quantum points. Week 3: Preparation of nanomaterials. Preparation of nanomaterials by bottom-up techniques: chemical syntheses (micelle method, reverse micelle method, sol-gel method, precipitation), self-assembly, controlled assembly: CVD method (chemical vapor deposition), MBE method (molecular beam epitaxy). Week 4: Preparation of nanomaterials by top-down techniques: cutting, grating, etching, lithography, SPD (spark plasma deposition).	

Week 5: Technical applications of nanomaterials in microelectronics, cosmetics, textiles, automotive, textiles, construction. Risks of using nanomaterials and nanotechnologies: harmful impact on the environment, health and safety.
Week 6: Magnetic nanomaterials. Characterization of structural properties of nanomaterials: XRD, TEM, HRTEM, XANES, EXAFS.
Week 7: Physical properties of nanomaterials. Quantum effect of particle size, quantization of magnetization, effect of monodomain particles.
Week 8: The phenomenon of superparamagnetism in magnetic nanomaterials. Behavior of spin glass, comparison of theoretical models and experiment.
Week 9: Magnetic nanomaterials in biotechnology and nano-medicine: drug carriers, DNA chips, materials for MRI (magnetic resonance imaging), nanomaterials in the treatment of cancer.
Week 10: Magnetic nanomaterials for industrial catalysis and gas separation: nanoparticles in ordered porous matrices.
Week 11: Magnetic nanomaterials in information-telecommunication technologies and optoelectronics: computer chips, high-density recording media, hard disks, memories, sensors, quantum cryptographs, photon crystals for quantum computers.
Week 12: Nanomagnetic models. Modeling of physical and structural properties of magnetic nanomaterials.
Week 13: Exam

Recommended literature:

1. Nanoscience and nanotechnologies, The Royal Society, London 2004.
2. C. Burda, X. Chen, et al., Chemical Review 105, (2005) 1025-1102.
3. J. A. Mydosh, Spin glasses, Taylor and Francis 1993.

Course language:
english

Notes:
Lectures can be done at presence form or online form using MS Teams. Education form is updated at the begining of the subject.

Course assessment
Total number of assessed students: 51

A	B	C	D	E	FX	N	P
37.25	0.0	0.0	0.0	0.0	0.0	0.0	62.75

Provides: doc. RNDr. Adriana Zeleňáková, PhD.

Date of last modification: 30.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ NAS/14	**Course name:** Nanoscopic systems
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 2.	
Course level: II.	
Prerequisities:	
Conditions for course completion: To successfully complete the course, the student must demonstrate sufficient knowledge of the nanotechnology with special emphasis on the chemical and physical principles, taking into account the knowledge defined in the course syllabus. The credit evaluation of the course takes into account the following student workload: 3 credits: exam in the form of an oral exam and a test	
Learning outcomes: Knowledge and understanding of nanotechnology with special emphasis on the physicochemical and physical principles in nanotechnology. Students gain knowledge in areas such as electronic structure of nanosystems, magnetic properties, dependence of thermodynamic properties on the size of the systems as well as an overview of the application potential of nanosystems and ethical implications of nanotechnology.	
Brief outline of the course: 1. The Origin of Nanomagnetic Behavior. 2. Sample Dimensions and Characteristic Lengths. 3. Dimensionality and Density of Electronic States. 4. Dimensionality and Reduced Coordination Number. 5. Nanoscopic Samples and Proportion of Surface Atoms. 6. Nanoscopic Samples and Magnetization Reversal. 7. Dimensionality and Critical Behavior. 8. Superparamagnetism. 9. Magnetic behavior of nanosystems at different temperature. 10. Termodynamical behavior of nanosystems. 11. The practical application of nanoscopic systems.	
Recommended literature: 1. Emil Roduner, Nanoscopic Materials: Size-Dependent Phenomena, RSC Publishing 2006, ISBN: 0 85404 857.	
Course language: slovak, english	

Notes:
Lectures can be done at presence form or online form using MS Teams. Education form is updated at the begining of the subject.

Course assessment
Total number of assessed students: 4

A	B	C	D	E	FX
75.0	25.0	0.0	0.0	0.0	0.0

Provides: doc. RNDr. Adriana Zeleňáková, PhD.

Date of last modification: 21.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ NERO/14	**Course name:** Neutron scattering in solids
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 2 / 1 **Per study period:** 28 / 14 **Course method:** present	
Number of ECTS credits: 4	
Recommended semester/trimester of the course: 3.	
Course level: II.	
Prerequisities:	
Conditions for course completion: The condition for passing the course is the elaboration of a semester work on a topic chosen at the beginning of the semester in the field of neutron scattering and an oral exam, which consists of theoretical questions from direct teaching. At the oral exam, the student also presents the results of their semester work, so it is important that the student continuously learns the content of the curriculum covered in the lecture. The credit evaluation of the course takes into account the following student workload: direct teaching (2 credits), self-study (1 credit) and assessment (1 credit). The minimum limit for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).	
Learning outcomes: Lectures are devoted to the description of experimental methods based on elastic and inelastic neutron scattering and its application in condensed matter physics and materials research. Analysis and interpretation of experimental data will be shown for specific cases.	
Brief outline of the course: 1. week: Properties of neutron, neutron scattering from a fixed point, cross section. 2. week: Law of neutron scattering, intensity of scattered neutrons. 3. week: Fermi's golden rule, coherent and incoherent scattering, dynamic structure factor. 4.-5. week: Diffraction, static structure factor, Bragg's law, reciprocal lattice. 6. week: small angle scattering, critical and diffusive scattering. 7. week: inelastic and quasi-elastic scattering. 8. week: Application of inelastic neutron scattering for the study of phonons and magnetic excitation spectra. 9. week: neutron source, two-axes and thee-axes spectrometer. 10. week: chopper time-of-flight spectrometer. 11. week: aplication of polarized neutrons. 12. week: determination of magnetic structure using neutrons.	
Recommended literature: 1. B.T.M. Willis, C.J. Carlile, Experimental Neutron Scattering, Oxford University Press Inc., New York, 2009	

2. Z. Smetana, V. Šíma, Neutronová difrakce, MFF UK, Praha, 1982
3. A.J. Dianoux, G. Lander, Neutron Data Booklet, OCP Science, Grenoble, 2003
4. R. Pynn, A Neutron Scattering Primer, LANCSE, Los Alamos, 1990

Course language:
english

Notes:
The course is realized in the full-time form, in if necessary remotely in the MS Teams.

Course assessment
Total number of assessed students: 14

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: RNDr. Róbert Tarasenko, PhD.

Date of last modification: 22.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ NKM1/99	**Course name:** Non-Conventionals Metallic Materials
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 1.	
Course level: II., III.	
Prerequisities:	
Conditions for course completion: For successful graduation of the subject student has to demonstrate relevant theoretical knowledge at final exam. Credit evaluation is composed of following parts: Taking part at the lectures – 1 credit, Self-study of recommended literature – 1 credit, Final exam – 1 credit. The final exam consist of written answers and oral discussion. The rating scale is determined as follow: A (90-100%), B (80-89%), C (70-79%), D (60-69%), E (50-59%), F (0-49%). Any changes related to form of teaching or in condition of subject completion will be communicated in the electronic board of the course.	
Learning outcomes: Student gain knowledge of fundamental theories of materials science, processing of metallic materials, essential knowledge and an overview about conventional and advanced metallic materials. The relationship between structure and physical/chemical/mechanical properties will be emphasized. Student earn the knowledge of modern practical applications of selected metallic alloys, mainly based on Fe, Ti, Al, Ni and Co. The principles and using of materials phenomena as well as methodology of new alloy designing will be significant part of acquired knowledge too.	
Brief outline of the course: Real metalic structures, Binary diagrams, Lattice imperfections, Hyperstructures, Streghtening mechanisms, Precipitation and segregation processes, Deformation mechanisms, Crystallization, Fe - based alloys, Advanced high-strenght alloys, Metallic biomaterials, Corrosive processes and materials for corrosion environment. Ti, Al, Co, Ni - based progressive materials, Materials dedicated to automotive, aircraft, military and nuclear industry, Superplasticity, Shape memory effect and its alloys, Materials for cryogenic applications, Intermetallics, Quasicrystals, High entropy alloys, Biodegradable metals, Metallic glasses.	
Recommended literature: W. D. Callister Jr., D. G. Rethwisch, Materials Science and Engineering: An Introduction, 10th Edition, ISBN 978-1-119-40549-8, (2018). R. Moravčík et al.: Úvod do materiálového inžinierstva I., ISBN 978-80-227-4405-8, (2015). L. Ptáček et al.: Náuka o materiálu I a II, ISBN 8072042483, (2002). Š. Nižník: Základy Fyziky tuhých látok, Učebné texty, Košice, (2002). M. Fujda: Základné rovnovážne diagramy, Učebné texty, košice, (2010).	

Course language:
Slovak language, English language

Notes:
Lectures are conducted in the presence form. In case of any circumstances, the lectures are turned to online form in specified communication platform.

Course assessment
Total number of assessed students: 42

A	B	C	D	E	FX	N	P
28.57	21.43	0.0	2.38	2.38	0.0	0.0	45.24

Provides: Ing. Vladimír Girman, PhD.

Date of last modification: 01.12.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice
Faculty: Faculty of Science

Course ID: ÚFV/ NOT1a/03	**Course name:** Nontraditional Optimization Techniques I

Course type, scope and the method:
Course type: Lecture / Practice
Recommended course-load (hours):
Per week: 2 / 2 **Per study period:** 28 / 28
Course method: present

Number of ECTS credits: 5

Recommended semester/trimester of the course: 1.

Course level: I., II.

Prerequisities:

Conditions for course completion:
Oral examination (50%), results and quality of the
personal presentation of the projects (50%).
Monitoring progress in solving applied projects. From given set of problems, the student must pick 1 to 3 projects and develop functioning implementation of the solution in form of computer program. In case of more challenging problems, collaborative work of students is acceptable, but each student must be able to present her/his individual contribution.

Learning outcomes:
To familiarize students with biologically and physically inspired optimization, simulation and prediction techniques. To expand students' creativity and programming skills by applying heuristic techniques in solving applied problems.
Upon successful completion of course, student shall possess knowledge about most typical non-traditional optimization techniques, as well as practical experience of solving concrete problems.

Brief outline of the course:
1. Fundamentals terms and definitions of optimization theory. Physical laws as optimization tasks. Variational principle.
2. Model optimization problems. Basic types of objective functions. Classification of optimization methods. Computational scaling of optimization methods. Big O notation. Parallelization, Metcalf's law, Amdahl's bottleneck.
3. Exhaustive search, Gradient-based optimization techniques.
4. Evolutionary algorithms. Canonical Genetic algorithm. Genetic algorithms as Markov processes. Statistical Mechanics description of Genetic Algorithms.
5. Monte Carlo simulation and simulated annealing. Metropolis algorithm and statistics of sampling in solution space.
6. Swarm optimization. Ant algorithms.
7. Cellular Automata and their applications in simulations of complex systems.
8. data structures and representation of solution space and optimization problems. Compression of information and symmetry. Manifolds.
9. Generators. grammars and languages. Genetic programming. AST and operations on AST representation of programs.

10. Fractals. Lindenmayer systems. Life-like and agent-based models.
11. Evolutionary games. Evolution of cooperation.
12. Fundamentals of Neural Networks. Stochastic gradient optimization.

Recommended literature:

Hartmann, A. K., Rieger, H., Optimization Algorithms in Physics, Wiley, 2002
Reeves, C. R., Rowe, J. E., Genetic Algorithms: Principles and perspectives, Kluwer, 2003
Mitchell, M., Complexity. A Guided Tour, Oxford University Press, 2009
Solé, R. V., Phase Transitions, Princeton University Press, 2011
Ilachinski, A., Cellular Automata. A Discrete universe, World Scientific, 2002
Haykin, S., Neural Networks. A Comprehensive Foundation, Prentice-Hall, 1999
Actual literature and data related to problem sets

Course language:

English language is essential for students as "lingua franca" for the latest advancements and applications of optimization techniques.

Notes:

The subject is taught using direct contact form. Should the epidemiological situation (or other relevant circumstances) mandate, the distant form will be used, preferentially using MS Teams learning environment.

Course assessment

Total number of assessed students: 99

A	B	C	D	E	FX
69.7	18.18	7.07	2.02	3.03	0.0

Provides: doc. RNDr. Jozef Uličný, CSc.

Date of last modification: 22.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ OVTL/21	**Course name:** Optical properties of solids

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 3 **Per study period:** 42
Course method: present

Number of ECTS credits: 4

Recommended semester/trimester of the course: 4.

Course level: II., III.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient knowledge of the optical properties of solids, taking into account the knowledge defined in the course syllabus.
The credit evaluation of the course takes into account the following student workload:
1 credits: direct teaching and self-study of recommended supplementary literature,
3 credits: exam in the form of an oral exam and a test.

Learning outcomes:
Students will gain knowledge in the field of optical properties of solids, with regard to the following knowledge: Optical properties of isotropic materials: Dielectric function of crystals, Symmetry of dielectric tensor, Neumann principle. Optical properties of anisotropic materials: Light propagation in anisotropic media, birefringence, optical activity, inversion center, calculation of counterclockwise and clockwise circularly polarized waves. Crystal symmetry from the perspective of optics. Distribution of crystals according to symmetry and from the point of view of anisotropy. Polarization catastrophe: Difference between local and macroscopic field, Clausio-Mossotti equation. Optical properties of ionic crystals: Susceptibility of ionic crystals, Dielectric function of ionic crystals, Collective modes in ionic crystals, Lyddan-Sachs-Teller (LST) relation, Ferroelectric instability.
Spontaneous and stimulated emission, Quantum theory of light, Luminescence in systems with localized electrons, fluorescence, Franck-Condon effect, luminescence in systems with delocalized electrons. Light scattering and photoemission: Rayleigh scattering, extinction length, critical opalescence, Optical fibers. Raman scattering: Stokes frequency, Selection rules for Raman scattering, Brillouin scattering. Photoemission: principle, presentation of angularly resolved photoemission experiments (ARPES) and their use for characterization of solids. Surface plasmon resonance (SPR) in nanosystems. Experimental methods based on dynamic light scattering. Experimental optical methods for characterization of solids.

Brief outline of the course:
1. Introduction lecture - reminder of terms: Optical constants, Description of the interaction of solids with light (Maxwell's theory, Lorentz-Drude microscopic theory, Semiclassical approach, Quantum description of interaction, Spintronics).

2. Optical properties of isotropic materials: Dielectric function of crystals, Symmetry of dielectric tensor, Optical frequencies, Neumann principle.
3. Optical properties of anisotropic materials: Light propagation in anisotropic media, birefringence, optical activity, inversion center, calculation of counterclockwise and clockwise circularly polarized waves.
4. Symmetry of crystals from the point of view of optics. Distribution of crystals according to symmetry and from the point of view of anisotropy. Polarization catastrophe: Difference between local and macroscopic field, Clausio-Mossotti equation.
5. Optical properties of ionic crystals: Susceptibility of ionic crystals, Dielectric function of ionic crystals, Collective modes in ionic crystals, Lyddan-Sachs-Teller (LST) relation, Ferroelectric instability.
6. Luminescence I: Spontaneous and stimulated emission, Quantum theory of light, Luminescence in systems with localized electrons, fluorescence
7. Luminescence II: Franck-Condon phenomenon, luminescence in systems with delocalized electrons.
8. Light scattering and photoemission: Rayleigh scattering, extinction length, critical opalescence, Optical fibers.
9. Raman scattering: Stokes frequency, Selection rules for Raman scattering, Brillouin scattering.
10 Photoemission: principle, presentation of angularly resolved photoemission experiments (ARPES) and their use for characterization of solids.
11. Surface plasmon resonance (SPR) in nanosystems: principle, practical application and demonstrations of experimental measurements using UV VIS method in the laboratory.
12. Experimental methods based on dynamic light scattering: measurement of nanoparticle size and surface charge (Zetapotential). Principle of the method and demonstrations in the laboratory.
13. Experimental optical methods for characterization of solids: Basics of FT-IR spectroscopy, Basics of Raman spectroscopy, ultrafast photoemission method, time-resolved optical microscopy.
14. Consultations, pre-term of the exam.

Recommended literature:

1. Fox M., Optical Properties of Solids, Oxford, 2001
2. Jan Soubusta, Antonín Černoch, Optical properties of solids, Palacky University, 2014.
3. R. Hlubina, Electrical and optical properties of solids, Komensky University 2018.

Course language:
english

Notes:
Lectures can be done at presence form or online form using MS Teams. Education form is updated at the begining of the subject. All ppt presentations are accesible in LMS UPJŠ.

Course assessment
Total number of assessed students: 4

A	B	C	D	E	FX	N	P
25.0	0.0	0.0	0.0	0.0	0.0	0.0	75.0

Provides: doc. RNDr. Adriana Zeleňáková, PhD.

Date of last modification: 21.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ FPK1/07	**Course name:** Phase Transitions and Critical Phenomena

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 3 **Per study period:** 42
Course method: present

Number of ECTS credits: 4

Recommended semester/trimester of the course: 2.

Course level: II.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student is required to understand the concept of phase transitions and critical phenomena based on thermodynamics and statistical physics. The successful graduate will be able to apply this apparatus to simpler models of magnetic systems using exact or approximate methods. The condition for obtaining credits is successful completion of the final oral exam. The credit evaluation of the course takes into account the following student workload: direct teaching (2 credits), self-study (1 credit), and assessment (1 credit). The minimum limit for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).

Learning outcomes:
To acquaint students with the basic problems of the theory of phase transitions and critical phenomena and their solutions using the methods of thermodynamics and statistical physics. Emphasis is placed on the study of phase transitions in magnetic systems, through several theoretical models, but the course also covers other areas such as phase transitions in nuclear matter.

Brief outline of the course:
1. Thermodynamics and phase transitions.
2. Conditions of stability of the equilibrium state of the magnetic system.
3. Phase equilibrium, phase transitions. Clausius-Clapeyron equation.
4. Classical (Ehrenfest) classification of phase transitions: phase transitions of the first and second kind.
5. Landau's description of phase transitions of the second kind.
6. Critical indices, universality. Definition of critical indices for the magnetic system. Thermodynamic relations between critical indices.
7. Basic microscopic models of magnetic phase transitions. Heisenberg and Ising model.
8. Exact solutions of microscopic models: one-dimensional and two-dimensional Ising model.
9. Thermodynamic functions for a one-dimensional Ising model.
10. Some approximate methods of solving the Ising model.
11. Landau's theory of phase transitions.
12. Phases of nuclear matter.

Recommended literature:

Basic literature:
BOBÁK, A., Phase Transitions and Critical Phenomena, Project 2005/NP1-051 11230100466, European Social Fund, Košice 2007.
STANLEY, H.G.: Introduction to Phase Transitions and Critical Phenomena, Clarendon Press Oxford, 1971.
Other literature:
REICHL, L.E.: A Modern Course in Statistical Physics, University of Texas Press, Austin, 1980.
PLISCHKE, M., BERGERSEN, B.: Equilibrium Statistical Physics, World Scientific, 1994.
KADANOFF, L.P.: Statistical Physics, Statistics, Dynamics and Renormalization, World Scientific, 2000.

Course language:
1. Slovak,
2. English

Notes:
The course is realized in the presence form, if necessary remotely in the MS Teams environment.

Course assessment
Total number of assessed students: 137

A	B	C	D	E	FX
54.74	11.68	11.68	14.6	7.3	0.0

Provides: prof. RNDr. Milan Žukovič, PhD.

Date of last modification: 19.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: KF/ FILA/22	**Course name:** Philosophical Antropology

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course:

Course level: II.

Prerequisities:

Conditions for course completion:

Learning outcomes:

Brief outline of the course:

Recommended literature:

Course language:

Notes:

Course assessment
Total number of assessed students: 0

A	B	C	D	E	FX
0.0	0.0	0.0	0.0	0.0	0.0

Provides: doc. PhDr. Kristína Bosáková, PhD.

Date of last modification: 01.02.2022

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ LEK1/02	**Course name:** Physical Principles of Medical Diagnostics and Therapy
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course: 1., 3.	
Course level: II.	
Prerequisities:	

Conditions for course completion:

To complete successfully the course, the student has to demonstrate the understanding of the basic notions and the physical principles of medical technology, especially of the diagnostic (imaging). In addition to attending classes, it is necessary for the student to study some specifics (details) of the discussed issues within self-study. The conditions for obtaining credits is, in addition to participation in teaching and passing the final exam, a successful completion of a written test. The minimum limit for passing the exam is to obtain 51% of the total score, which takes into account all required activities. The credit evaluation takes into account the following student workload: direct teaching - 1 credit, self-study of recommended literature - 1 credit, continuous study for the test and evaluation - 1 credit.

Rating scales: A - 91% -100% points, B - 81% -90% points, C - 71% -80% points, D - 61% -70% points, E - 51% -60% points.

Learning outcomes:

After completing the lectures, the student will have the knowledge to understand the principles and operation of modern medical devices, such as e.g. ultrasound diagnostics, computed transmission tomography, computed emission (positron) tomography, magnetic (resonance) tomography, radiotherapy and lasers, and to be able to explain the principles and use of the facilities to others. The acquired knowledge should also be a good prerequisite for a possible employment of the student in companies producing or operating modern medical technology.

Brief outline of the course:

1. Division of medical technology into diagnostic and therapeutic. A brief history of medical technology.
2. Ultrasound diagnostics (USG). Basic terms - used frequencies, wave intensities, acoustic impedance, ultrasound generation, absorption of ultrasonic waves, reflection and refraction of waves, space resolution, focusing of waves. Types of ultrasound imaging: type A and B imaging, creation of a dynamic (real time) image, time imaging (time motion). Some methods of signal processing: digitization, time-dependent signal balancing, etc.
3. Ultrasound diagnostics based on Doppler effect. Systems with unmodulated and modulated carrier waves, examination of blood flow in the organism. Possibilities of ultrasound diagnostics and

its advantages. Interaction of ultrasound with tissues (active and passive), principles of ultrasound therapy.
4. Transmission computed tomography (CT). Absorption of X-rays in tissues, evaluation of relationships between the intensity of incident and the intensity of penetrated radiation, image constructions.
5. Construction of a CT equipment, X-ray source, detection system, evaluation and processing of results. Types (generations) of CT devices. Implementation of CT examination and image evaluation. 6. Emission computed tomography (ET). Single-photon emission tomography - selection of suitable radionuclides and evaluation of the distribution of radionuclides in the body.
7. Construction of emission tomograph, benefits and use of emission tomography. Positron emission tomography (PET). Positron emitters, positron - electron annihilation, coincident photon detection. Construction of PET equipment, benefits and use of PET.
8. Thermography - basic concepts. Contact thermography - properties of liquid crystals, detection of changes in surface temperature of an organism. Contactless thermography. Radiation of bodies, detection of infrared radiation, distribution and properties of detectors. Thermograph design, use of thermography in medicine and other areas.
9. Magnetic (resonance) tomography (MR/MT). Principles of nuclear magnetic resonance - magnetic moment of the nucleus, movement (precession) of magnetic moments in magnetic field. Longitudinal and transverse relaxation times, causes of their change. Methods of measuring relaxation times.
10. Acquisition of image information - use of magnetic field gradients, methods of their creation. Design of magnetic tomographs - basic magnet, high frequency coils, shielded rooms, evaluation systems. Possibilities and use of MT, the use of contrast agents.
11. Lasers in medical technology. Principle of laser operation, spontaneous and induced emission, three-level lasers (solid, gas), construction of lasers. Properties of laser radiation and the effect of laser beam on biological objects (tissues). Use of lasers in various fields of medicine.
12. Principles of radiotherapy. Interaction of various ionizing particles (photons, electrons, neutrons, protons) with the environment. Biological effects of ionizing radiation, applied doses, survival curves. New methods of irradiation, the use of Bragg maximum in hadron irradiation therapy, neutron capture therapy. Possibilities of ionizing radiation beam modification.

Recommended literature:

- Režňák I. et al., Modern imaging methods in medical diagnostics, Vyd. Osveta, Martin, 1992.
- Jurga Ľ. et al., Basics of Medical Radiology, Script of LF UPJŠ, Košice, 1990.
- Mc Ainsh T.F., Physics in Medicine and Biology, Pergamon Press, Oxford, 1987.
- Huda W., Slone R.M., Review of Radiologic Physics, Lippincot, London, 1995
- Bushberg J.T, et al., The essential physics of imaging, Lippincott Williams, Philadelphia, 2002.

Course language:

Slovak, English

Notes:

Recommended range of lessons (in hours): Weekly: 2/0
For the period of study: 26/0
Method of study: Teaching is carried out in person, if necessary remotely, in the environment of MS Teams.
Number of ECTS credits: 3
Degree of studz: I. resp. II.
Prerequisites: none

Course assessment
Total number of assessed students: 42

A	B	C	D	E	FX
88.1	9.52	2.38	0.0	0.0	0.0

Provides: doc. RNDr. Karol Flachbart, DrSc.

Date of last modification: 06.10.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ FRKP/19	**Course name:** Physical realization of quantum computer

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 2., 4.

Course level: II.

Prerequisities: ÚFV/KVM I/11

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient understanding of the basic principles of quantum algorithms, superposition, interference and entanglement, but most importantly physical principles and technical details of state-of-the-art realizations of qubits. To obtain credits, students are required to prepare a presentation about one of the qubit realizations and pass an oral examination. The credit evaluation of the course considers the following student workload: direct teaching (1 credit), self-learning and presentation preparation (1 credit), assessment (1 credit). The minimum threshold for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60-69%), E (50-59%), F (0-49%).

Learning outcomes:
The course provides a basic overview of quantum algorithm principles and various ways of qubit realization e.g., Josephson junctions, trapped ions, quantum dots, topological qubits etc., their physical principles, technical specifications, control and readout methods.

Brief outline of the course:
Topics 1-9 lectured by Mgr. T. Samuely, PhD., topics 10-12 lectured by doc. RNDr. E. Čižmár, PhD.
1. General Introduction: two state quantum system, superposition, Bloch sphere.
2. General Introduction: Quantum entanglement, decohorence, multi-qubit system.
3. General Introduction: Digital vs. analog quantum computer, quantum algorithms, overview of used techniques.
4. Qubits based on trapped atoms and ions. Experimental methods of preparation, unitary operations and quantum measurement.
5. Qubits based on Josephson junctions. Brief introduction to superconductivity, Josephson effect. Experimental methods of preparation, unitary operations, and quantum measurement.
6. Spin polarization and superconductivity.
7. Topological phases, Majorana bound states and non-Abelian anyons.
8. Topologically protected qubits, computation methods (braiding) and properties.
9. Qubits based on quantum dots. Experimental methods of preparation, unitary operations, and quantum measurement.
10. Magnetic resonance as a tool for quantum computing.

11. Microwave resonators, quantum circuits.
12. Qubits based on molecular magnets and nitrogen vacancies. Experimental methods of preparation, unitary operations, and quantum measurement.

Recommended literature:
1. Michael A. Nielsen & Isaac L. Chuang: Quantum Computation and Quantum Information 10th Anniversary Edition, Cambridge University Press, Cambridge, UK 2010
2. www: quantum.country
3. Tudor D. Stanescu: Introduction to Topological Quantum Matter & Quantum Computation, Boca Raton, FL, CRC Press, Taylor & Francis Group 2017
4. Philip Krantz et al.: A quantum engineer's guide to superconducting qubits, Appl. Phys. Rev. 6, 021318 (2019)
5. www: quantumcomputingreport.com
6. recent papers

Course language:
Slovak, English

Notes:
The course comprises onsite lectures. If necessary, online lectures will be provided via MS Teams.

Course assessment
Total number of assessed students: 4

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: Mgr. Tomáš Samuely, PhD., univerzitný docent, doc. RNDr. Erik Čižmár, PhD.

Date of last modification: 28.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ FTV/14	**Course name:** Physics and technics of vacuum

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 3.

Course level: II.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient understanding of the basic concepts in the description of volume properties of gas and gas flow at low pressures, understanding of technical solutions in vacuum technology.
The credit evaluation of the course takes into account the following student workload: direct teaching (1 credits), self-study (1 credits) and assessment (1 credits). During the semester, the student must continuously master the content of the curriculum and pass the final test with a minimum success rate of 50%, evaluation scale: A (90-100%), B (80-89%), C (70-79%), D (60-69%), E (50-59%), F (0-49%).

Learning outcomes:
Overview of basic topics in vacuum physics - volume transport properties of gas, gas flow, gas on solids. Principles of the measurement and creation of low pressure conditions. Basics of the vacuum equipment construction and the leak-tightness testing. The use of vacuum technology in advanced material preparation and cryogenics.

Brief outline of the course:
1. Overview of the basic topic in low pressure physics based on the kinetic theory of gases. Mean-free path, energy distibution of gas particles.
2. Volume transport properties of gas - diffusion, viskosity.
3. Volume transport gas properties - thermal conductivity and thermal transpiration.
4. Gas flow, definition of throughput and conductivity. Viscous flow.
5. Molecular flow. Viscous-molecular flow.
6. Surface effects, adsorbtion and desorbtion, adsorbtion isoterms.
7. Non-equillibrium surface effects. Transport of adsorbed molecules, migration, evaporation.
8. Gas flow through leak - capillary, capillary condensation, gas flow through porous material. Permeation.
9. Characterization of the pumping system.
10. Low-pressure production - mechanical (rotary vane pump, Roots pump, oil-vapor diffusion pump, turbomolecular pump), ion, sorbtion pumps.
11. Total and partial pressure measurement.
12. Leak testing methods, mass spectrometer, design of vacuum ducts.

Recommended literature:
L. Pátý, Fyzika nízkých tlaku, Academia, Praha, 1968;
P. Lukáč, V. Martišovič, Netesnosti vákuových systémov, ALFA, Bratislava, 1980;
J.F. O'Hanlon, A User's Guide to Vacuum Technology, Wiley-Interscience; 2003;

Course language:
Slovak, partially English

Notes:
Teaching is carried out in person or remotely using the MS Teams tool. The form of teaching is specified by the teacher, updated continuously.

Course assessment
Total number of assessed students: 20

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: doc. RNDr. Erik Čižmár, PhD.

Date of last modification: 18.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ PP1/99	**Course name:** Physics of Semiconductor Elements

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 3.

Course level: II.

Prerequisities:

Conditions for course completion:
To successfully complete the course (presence, if necessary distance), the student must demonstrate sufficient understanding of the concepts, phenomena and laws of physics in the transport of electric charge in semiconductors, construction and function of semiconductor components and know the principles of their production. Knowledge of the basic possibilities of using semiconductor components in electronic circuits and devices is also required.
Credit assessment takes into account the scope of teaching (2 hours of lectures) and self-study (1 credit).
The minimum limit for successful completion of the course is to obtain 50 points in the oral exam from the subsequent point evaluation
Rating scale
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
After completing the lectures and taking the exam, the student will have in-depth knowledge of the transport of electric charge in semiconductors, the construction and function of semiconductor components and will know the principles of their production. He will also acquire basic knowledge about the possibility of using semiconductor components in electronic circuits and devices.

Brief outline of the course:
1. Week. Characteristics and content of the course. Division of semiconductor components. Basic properties of semiconductors.
2. Week. Components based on bulk effects in semiconductors: thermistors, Hall components, magnetoresistors, cryosars, Gunn diodes, varistors, strain gauge semiconductor components.
3. Week. Semiconductor components with one PN junction: rectifier diodes, stabilization diodes, tunnel and inverse diodes

4. Week. Semiconductor components with one PN junction: varicaps and varactors, thermoelectric cells, unijunction transistor. Types and construction of diodes.
5. Week. Semiconductor devices with two PN junctions: bipolar transistor. Principle of operation, properties, types of transistors and their construction.
6. Week. Components with more PN junctions: four-layer and five-layer components, the principle of their operation, properties and construction.
7. Week. Components based on effects at the metal-semiconductor interface: Schottky diode, diode with limited space charge.
8. Week. Junction field effect transistors, principle of operation and construction.
9. Week. Metal-insulator-semiconductor field effect transistor, basic characteristics and construction, thin film MIS transistors.
10. Week. Semiconductor components in integrated circuits: resistor, capacitor, diode, transistor.
11. Week. Technology of semiconductor components, production.
12. Week Optoelectronic components. Light sources: light emitting diodes, semiconductor lasers. Light detectors: photoresistors, photodiodes, PIN avalanche photodiodes, phototransistors.
13. Week Charge-coupled devices.

Recommended literature:

D. J. Roulston, An introduction to the physics of semiconductor devices, Oxford University Press, 1999
R. Dalven: Introduction to Applied Solid State Physics, Plenum publishing corporation New York, 1990

Course language:

english

Notes:

Presence form represents a standart form for the course, if a need arises, the course is performed using MS Teams.

Course assessment

Total number of assessed students: 26

A	B	C	D	E	FX
73.08	19.23	7.69	0.0	0.0	0.0

Provides: prof. RNDr. Peter Kollár, DrSc.

Date of last modification: 22.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ PCHZ/14	**Course name:** Preparation and characterization of metalic alloys
Course type, scope and the method: **Course type:** Practice **Recommended course-load (hours):** **Per week:** 3 **Per study period:** 42 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 3.	
Course level: II.	
Prerequisities:	
Conditions for course completion: To successfully complete the course, the student must demonstrate sufficient understanding of the basics aspect of preparation and characterization of metallic alloys. The course consists of three blocks of laboratory exercises. In the first block, students will get acquainted with the preparation of metal alloys, in the second students will perform mettalic alloy characterization and in the third block students will prepare composite material based on prepared alloy using planetary milling. To obtain the evaluation, the student must complete all three consecutive blocks of exercises and submit a report from the exercise, which the teacher evaluates with a point evaluation. The minimum threshold for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).	
Learning outcomes: The ability to prepare metal alloys in the form of bulk samples by arc melting, casting in a copper mold, and casting using a rotating copper cylinder. Preparation of powder samples by milling and preparation of compressed powder samples. Student will learn how to use EDAX spectroscopy and scanning electron microscopy to characterize metallic alloys.	
Brief outline of the course: Production of alloys using arc melting. Production of alloys using casting into a copper mold. Production of alloys using melt spinning method. Production of alloys by milling of precursor. Theoretical introduction to the preparation of metal alloys and work with binary diagrams of metal alloys. Calculation of the chemical composition of the metal alloys and weighing of the chemical elements. Arc melting of metal alloys. Preparation of alloys in the form of ribbons by casting a molten alloy on a rotating copper cylinder. Production of alloys by milling of precursor. Milling in a ball mill and in a planetary mill. Milling at room temperature and milling at temperature of liquid nitrogen. Production of pressed powder materials. Scanning electron microscopy, the principle of scattering of materials in solids, detectors, demonstration of the resolution of individual types of detectors. Principle of energy-dispersion analysis and practical demonstration on a prepared sample.	
Recommended literature: Hilzinger R, Rodewald W, Magnetic materials, Vacuumschmelze, 2013 Chen CW, Magnetism and metalurgy of soft magnetic materials, Dover publications, 1986	

Course language:
slovak or english

Notes:
Teaching is carried out full-time or part-time using the MS teams platform. Form of teaching are specified by the teacher at the beginning of the semester and continuously updated as needed.

Course assessment
Total number of assessed students: 20

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: Mgr. Vladimír Komanický, PhD., univerzitný docent, doc. RNDr. Ján Füzer, PhD., RNDr. Ladislav Galdun, PhD.

Date of last modification: 28.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ KTM/14	**Course name:** Quantum Theory of Magnetism
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 3 **Per study period:** 42 **Course method:** present	
Number of ECTS credits: 5	
Recommended semester/trimester of the course: 3.	
Course level: II., III.	
Prerequisities:	

Conditions for course completion:

To successfully complete the course, the student must demonstrate sufficient understanding of the basics terms, concepts, and applications of quantum theory of magnetism. Knowledge of basic concepts of quantum physics at the level of their mathematical definition is required, as well as understanding of their physical content and specific applications in the field of magnetism. During the semester, the student must continuously master the content of the curriculum, so that he can actively and creatively use the acquired knowledge in solving specific tasks assigned to independent solutions at home. The condition for obtaining credits is passing an oral exam, which consists of one more demanding computational task and theoretical questions covering the entire scope of the course. The credit evaluation of the course takes into account the following student workload: direct teaching (2 credits), self-study (1 credit), individual consultations (1 credit) and assessment (1 credit). The minimum threshold for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).

Learning outcomes:

After completing lectures, the student will have sufficient physical skills, knowledge and mathematical apparatus enabling independent solution of a wide range traditional and current scientific problems in quantum theory of magnetism. At the same time, he will gain an
overview of the applications of quantum theory of magnetism for a description of insulating magnetic materials.

Brief outline of the course:

1. Introduction to quantum theory of magnetism, definition of basic lattice-statistical models in magnetism: Ising model, Heisenberg model, Hubbard model, t-J model.
2. Exchange interaction and its quantum-mechanical origin. Formalism of the second quantization and basic commutation relations between ladder spin operators.
3. Elementary quantum theory of a pair of interacting magnetic particles: Heisenberg dimer.
4. Elementary quantum theory of a pair of interacting magnetic particles: Hubbard dimer.
5. One-dimensional quantum Heisenberg model, spin waves as collective excitations of ferromagnetic spin chain, one-magnon spectrum.

6. One-dimensional quantum Heisenberg model with ferromagnetic interaction, two-magnon spectrum, free and bound spin waves, basics of Bethe-ansatz method.
7. Crystal of singlet dimers as a basic state of frustrated quantum Heisenberg models (Majumdar-Ghosh model and Gelfand ladder).
8. Fermionization of one-dimensional quantum XX model in transverse magnetic field: Jordan-Wigner and Fourier transform. Quantum critical point and thermodynamic behavior.
9. Fermionization of one-dimensional quantum Ising model in transverse magnetic field: Jordan-Wigner, Fourier and Bogoliubov transformation.
10. Variational description of quantum phase transitions in dimerized quantum Heisenberg spin models.
11. Theory of localized magnons as a tool for a simple description of the thermodynamic behavior of frustrated quantum Heisenberg models at nonzero temperatures.
12. Spin-wave theory for a generalized quantum Heisenberg model of arbitrary spatial dimension and spin size. Bosonization through the Holstein-Primakoff transformation.

Recommended literature:

1. J. B. Parkinson, D. J. J. Farnell, An Introduction to Quantum Spin Systems, Lecture Notes in Physics 816 (Springer, Berlin Heidelberg, 2010).
2. U. Schollwock, J. Richter, D. J. J. Farnell, R. F. Bishop, Quantum Magnetism, Lecture Notes in Physics 645 (Springer, Berlin Heidelberg, 2004).
3. N. Majlis, The Quantum Theory of Magnetism (World Scientific, Singapore, 2000).

Course language:
EN - english

Notes:
The subject is realized in presence form, in case of need in distance form in MS Teams enviroment.

Course assessment
Total number of assessed students: 31

A	B	C	D	E	FX	N	P
12.9	32.26	12.9	3.23	12.9	3.23	6.45	16.13

Provides: doc. RNDr. Jozef Strečka, PhD.

Date of last modification: 19.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ KSF/22	**Course name:** Quantum statistical physics

Course type, scope and the method:
Course type: Lecture / Practice
Recommended course-load (hours):
Per week: 2 / 2 **Per study period:** 28 / 28
Course method: present

Number of ECTS credits: 5

Recommended semester/trimester of the course: 1., 3.

Course level: II.

Prerequisities:

Conditions for course completion:

To successfully complete the course, the student must demonstrate sufficient understanding of all basic cconcepts and applications of quantum statistical physics. Knowledge of basic concepts of quantum statistical physics at the level of their mathematical definition is required, as well as their physical content and fundamental applications. The student must be able to actively master the content of the curriculum continuously during the semester, so that he can actively and creatively use the acquired knowledge in solving specific problems during exercises and for independent homework. In addition to direct participation in lectures, the student is obliged to study within the self-study professional topics assigned by the teacher and also to develop and present two homework assignments. The condition for obtaining credits is, in addition to participation in lectures, also the successful completion of three written tests from exercises and lectures and the elaboration of home assignments. The minimum limit for passing the exam is to obtain 51% of the total score, which takes into account all required activities with relevant weight.
Rating scale: A - 91% -100% points, B - 81% -90% points, C - 71% -80% points,
D - 61% -70% points, E - 51% -60% points.

Learning outcomes:

After completing lectures and exercises, the student will have sufficient physical knowledge and mathematical apparatus to independently solve a wide range of current scientific problems in various fields of physics, especially in the field of condensed matter physics and materials research. In addition to solving traditional physical problems, the student will be able to creatively apply the methods of quantum statistical physics in solving various practical problems. These are mainly practical applications in the field of quantum algorithms and calculations, in the field of life sciences (spread of dangerous infectious diseases), but also in the field of big data processing, in the social and political sciences (election results prediction). The graduate will also be able to solve specific application tasks in the field of informatics, including the creation of various software products.

Brief outline of the course:

1. Basic concepts of quantum statistical physics. Pure and mixed quantum statistical ensembles. Definition of statistical density matrix. Liouville's theorem for the density matrix. Equilibrium / mean values in quantum statistical physics.

2. Quantum microcanonical statistical ensemble. Density matrix in a microcanonical ensemble. Quantum theory of independent lattice harmonic vibrations in the microcanonical ensemble. Entropy, internal energy, free energy and heat capacity of the crystal lattice within microcanonical ensemble.
3. Quantum canonical set. Density matrix for the canonical ensemble. Partition function, von Neuman entropy, internal and free energy in a canonical ensemble. Quantum theory of independent lattice harmonic vibrations in the ensemble set. Entropy, internal energy, free energy and heat capacity of the crystal within canonical ensemlbe. Relationship between microcanonical and canonical ensemble.
4. Quantum theory of paramagnetism in the canonical ensemble. Magnetization, susceptibility, entropy, internal energy, enthalpy and heat capacity of a paramagnetic crystal.
5. Interacting systems. Bogoľubov inequality and mean field theory for the ferromagnetic transverse Ising model on an arbitrary crystal lattice.
6. Quantum grand-canonical ensemble. Density matrix and grand-canonical partition function, entropy and grand-canonical potential
7. Ideal gases in quantum statistical physics. Density of quantum states and quasiclassical approximation. Fermi-Dirac and Bose-Einstein statistics. Classical limit of quantum statistics - Boltzmann statistics. Quantum statistics of relativistic ideal gases.
8. Applications of the Fermi-Dirac distribution. Completely and partially degenerate fermion gas.
9. Stability of degenerate stars. Radius of white dwarfs. Chandrasekhar's criterion. Radius of neutron stars. Oppenhaimer-Volkov criterion.
10. Applications of the Bose-Einstein distribution. Radiation of an absolutely black body. Rayleigh-Jeans law, Planck's law, Wien's shift law and Stefan-Boltzmann's law.
11. Bose-Einstein condensate. Formation of the Bose-Einstein condensate and its heat capacity. Helium superfluidity. Superconductivity. Green's functions. Solving the Bloch equation using Green 's functions.
12. Integral equations for the density operator. Einstein's theory of fluctuations. Correlation of fluctuations. Onsager reciprocity relations.

Recommended literature:

1. F. Čulík, M. Noga: Úvod do štatistickej fyziky a termodynamiky, Alfa, Bratislava 1992.
2. J. Kvasnica: Statisticka fyzika, Academia, Praha, 1998.
3. W. Greiner, L. Neise, H. Stöcker: Thermodynamics and Statistical Physics, Springer, New York 1994.
4. L. E. Reichel: A Modern Course in Statistical Physics, University of Texax Press, Austin 1980.

Course language:
slovak, english

Notes:

Course assessment
Total number of assessed students: 9

A	B	C	D	E	FX
77.78	0.0	22.22	0.0	0.0	0.0

Provides: prof. RNDr. Michal Jaščur, CSc.

Date of last modification: 19.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice
Faculty: Faculty of Science
Course ID: ÚFV/ RPM/14 — **Course name:** Relaxation processes in molecular magnets

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course: 1., 3.

Course level: II.

Prerequisities:

Conditions for course completion:
Continuous active acquisition of the subject is required during the course Relaxation Processes in Molecular Magnets, which is necessary for independent elaboration of individual tasks in self-study and in solving specific homework. During the semester, the student gets one independent project based on the study of foreign journal literature and the Internet (e.g. a more detailed study of the corresponding physical phenomenon related to given relaxation process, or understanding a specific scientific article and based on it elaboration and presentation). Another condition for completing the course is active participation in lectures. Subsequently, the student independently analyzes the experimental data of the selected compound in one (or after consultation with the teacher up to two) home projects and presents the results of the analysis at a joint meeting. Another condition for obtaining credits is successful completion of the exam from the theoretical part in the form of an oral discussion, where the student demonstrates an understanding of basic concepts and relationships between them. The minimum threshold for completing the course is successful completion of self-study projects and individual assignments during the semester and mastering the final oral exam by more than 50 percent.

Learning outcomes:
After completing the course, students will gain a basic knowledge that will allow them to sufficiently orient themselves in the current scientific literature focused on the study of lattice and spin dynamics. This area is currently very topical, especially due to current developments in quantum technology, where it is important to find suitable materials that are characterized by very slow spin and lattice relaxation as one of the basic prerequisites for the stability of q-bit based on spin paramagnets.

Brief outline of the course:
1. Interactions of electronic spin with surrounding. Spin-spin interactions. Dipolar and Exchange coupling.
2. Relaxation time of a two-level system. Interaction of spin with electromagnetic field. Einstein coefficients.
3. Spin-lattice relaxation due to phonons – Waller's mechanism. Direct process. Raman process.
4. Spin-lattice relaxation due to crystal field modulation. Direct process. Orbach process.
5. Raman process of the first order. Raman process of the second order. Orbach-Blume process.

6. Phonon bottleneck effect.
7. Thermally activated magnetic relaxation.
8. Superparamagnetism. Neél-Arhenious relation. Blocking temperature.
9. Relaxation due to quantum tunneling. Thermally assisted quantum tunnelling.
10. Relaxation processes due to localized modes. E´ centres. „Rattling“ modes. Optical modes.
11. Casimir and du Pré theory. Ac susceptibility. Cole-Cole diagram. Debye relaxation. Distribution of relaxation times.
12. Examples of spin-lattice relaxation in molecular and single-ion magnets. Relaxation phenomena observed using various experimental techniques.

Recommended literature:
1. D. Gatteschi et al. Molecular Nanomagnets, Oxford University Press, 2006.
2. A. Abragam and B. Bleaney, Electron Paramagnetic Resonance of Transition Ions, Clarendon Press Oxford 2012.
3. Scientific papers

Course language:
english

Notes:
The course Relaxation processes in molecular magnets is realized in the attendance form. In some special cases (as was pandemics of Covid) the teaching is realized online using software MS Teams, which enables to keep the contact with students and to keep the level and quality of the course.

Course assessment
Total number of assessed students: 4

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: doc. RNDr. Alžbeta Orendáčová, DrSc.

Date of last modification: 22.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚTVŠ/ ÚTVŠ/CM/13	**Course name:** Seaside Aerobic Exercise
Course type, scope and the method: **Course type:** Practice **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course:	
Course level: I., II.	
Prerequisities:	
Conditions for course completion: Completion: passed Condition for successful course completion: - active participation in line with the study rule of procedure and course guidelines - effective performance of all tasks- aerobics, water exercise, yoga, Pilates and others	
Learning outcomes: Content standard: The student demonstrates relevant knowledge and skills in the field, which content is defined in the course syllabus and recommended literature. Performance standard: Upon completion of the course students are able to meet the performance standard and: - perform basic aerobics steps and basics of health exercises, - conduct verbal and non-verbal communication with clients during exercise, - organise and manage the process of physical recreation in leisure time	
Brief outline of the course: Brief outline of the course: 1. Basic aerobics – low impact aerobics, high impact aerobics, basic steps and cuing 2. Basics of aqua fitness 3. Basics of Pilates 4. Health exercises 5. Bodyweight exercises 6. Swimming 7. Relaxing yoga exercises 8. Power yoga 9. Yoga relaxation 10. Final assessment Students can engage in different sport activities offered by the sea resort – swimming, rafting, volleyball, football, table tennis, tennis and other water sports in particular.	
Recommended literature: 1. BUZKOVÁ, K. 2006. Fitness jóga. Praha: Grada. 167 s.	

2. ČECHOVSKÁ, I., MILEROVÁ, H., NOVOTNÁ, V. Aqua-fitness. Praha: Grada. 136 s.
3. EVANS, M ., HUDSON, J., TUCKER, P. 2001. Umění harmonie: meditace, jóga, tai-či, strečink. 192 s.
4. JARKOVSKÁ, H., JARKOVSKÁ, M. 2005. Posilováni s vlastním tělem 417 krát jinak. Praha: Grada. 209 s.
5. KOVAŘÍKOVÁ, K. 2017. Aerobik a fitness. Karolium, 130 s.

Course language:
Slovak language

Notes:

Course assessment
Total number of assessed students: 54

abs	n
11.11	88.89

Provides: Mgr. Agata Dorota Horbacz, PhD.

Date of last modification: 29.03.2022

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: KF/ FIVYC/22	**Course name:** Selected Topics in Philosophy of Education (General Introduction)
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 1 / 1 **Per study period:** 14 / 14 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course:	
Course level: II.	
Prerequisities:	
Conditions for course completion:	
Learning outcomes:	
Brief outline of the course:	
Recommended literature:	
Course language:	
Notes:	
Course assessment Total number of assessed students: 2	

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: PhDr. Dušan Hruška, PhD.	
Date of last modification: 27.04.2022	
Approved: prof. Ing. Martin Orendáč, DrSc.	

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ VPM/18	**Course name:** Selected problems of numerical methods in micro- magnetism
Course type, scope and the method: **Course type:** Lecture **Recommended course-load (hours):** **Per week:** 1 **Per study period:** 14 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course: 2., 4.	
Course level: II., III.	
Prerequisities:	

Conditions for course completion:

To successfully complete the course, the student must understand the basics of micromagnetic simulations. They must know the basic functions of the OOMMF simulation environment and create simple scripts, as well as process the outputs of these simulations. The final assessment is given on an oral exam.

Final assessment takes into account the scope of teaching (2 credits), consultations and assessment (1 credit).

Grading scale: A - 91%-100% points, B - 81%-90% points, C - 71%-80% points ,D - 61%-70% points, E - 51%-60% points.

Learning outcomes:

After completing the lectures, the student will have knowledge of creating micromagnetic simulations of simple systems. It will be able to run these simulations using scripting, thus automating the process.

Brief outline of the course:

1. Introduction to micromagnetic simulations. Equation of motion of a magnetic moment in external magnetic field. Effective field. Gibbs free energy. Langevin dynamics. Characteristic length of scaling. Numeric methods in micromagnetism. Discretization, final elements. Calculation of a magnetostatic fields. Time integration.
2. Simulation software OOMMF. OOMMF architecture overview. Scripting by command line. Scripting using Python. Parallelization of solution. Input/output parameters of scripting.
3. OOMMF solver – description of a child classes Atlases, Meshes, Energies, Evolvers, Drivers and Field objects.
4. Output of simulations, description of tools mmDataTable, mmDataGraph, mmDisp and mmArchive.
5. Conversion of outputs, conversion of three-dimensional vector fields into bmp, postscript and data tables. Description of *.mif format. Material parameters, initial magnetization, demagnetization fields, parameters of simulations, stop criteria of simulations.
6. Simulation of a domain wall in thin magnetic wire. Compensation of a stray fields produced by free ends of a wire. Various initial spin structures of a domain wall.

7. Simulation of hysteresis loops of nanowires, Circular discs. Implementation of temperature in a micromagnetic solver.

Recommended literature:

1. A. Friedman, Micromagnetic simulation v: Mathematics in Industrial Problems. The IMA Volumes in Mathematics and its Applications, vol 57. Springer, New York, NY
2. S. Chikazumi, Physics of Ferromagnetism, Oxford University Press, USA (2009)
3. A. Prohl, Computational Micromagnetism v: Advances in Numerical Mathematics, ISSN 1616-2994, Springer, New York, NY

Course language:
Slovak, English

Notes:
The course is realized via on-site lectures, if necessary, online via MS Teams.

Course assessment
Total number of assessed students: 0

A	B	C	D	E	FX	N	P
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Provides: RNDr. Kornel Richter, PhD.

Date of last modification: 28.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ SPFKLa/14	**Course name:** Semestral work I

Course type, scope and the method:
Course type:
Recommended course-load (hours):
Per week: Per study period:
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course: 1.

Course level: II.

Prerequisities:

Conditions for course completion:
Successful completing the course, requires the student to demonstrate adequate level of the assigned tasks set by the project leader at the beginning of the semester to the required extent and at the required level. The assignments are formulated by the teacher at the beginning of the semester, the project leader is usually the supervisor of the final thesis. Tasks include e.g. study of literature in the field, mastering the operation of experimental equipment, sample preparation technology, preparation and implementation of the experiment, processing of the obtained data, or collaborating during the preparation of a scientific publication. Credit evaluation takes into account the time requirements of the student when working on a semester project in the range of 50 hours per semester. Individual activities of the student are evaluated by the project leader, the overall work of the student is evaluated by points on a point scale of 0 - 100 points. The minimum threshold for obtaining a rating is 50% of the rating scale, which is determined as follows:
A 100-91%
B 90-81%
C 80-71%
D 70-61%
E 60-50%
Fx 49-0%

Learning outcomes:
After completing the course, the student will acquire knowledge and skills associated with scientific work in the field of condensed matter physics. By actively participating in individual research teams, students will extend their knowledge of physics in the relevant part of condensed matter physics, acquire experimental skills in operating contemporary scientific equipment, study of the literature will improve their language skills. Data processing resp. the creation of original software will improve their computer skills.

Brief outline of the course:
Program for semestral project is prepared individually for each student by supervisor of the project at the beginning of each semester and can be focused on search in literature for a selected area of research, preparation of experiment and its performing, creation of software for data acquisition

and analysis, collaboration during preparation of manuscript, presentation of the obtained results for department audience. Supervisor of the project will specify the topic of the project.

Recommended literature:
Selected scientific journals and books.

Course language:
slovak, english

Notes:
Subject Semester work I is realized in attendance form. If necessary (e.g. Covid pandemic) it is taught online using software MS Teams, which allows to maintain contact with students even in adverse conditions and also allows to meet the requirements of the subject.

Course assessment
Total number of assessed students: 33

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 24.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ SPFKLb/14	**Course name:** Semestral work II
Course type, scope and the method: **Course type:** **Recommended course-load (hours):** **Per week: Per study period:** **Course method:** present	
Number of ECTS credits: 6	
Recommended semester/trimester of the course: 2.	
Course level: II.	
Prerequisities: ÚFV/SPFKLa/14	

Conditions for course completion:

Successful completing the course, requires the student to demonstrate adequate level of the assigned tasks set by the project leader at the beginning of the semester to the required extent and at the required level. The assignments are formulated by the teacher at the beginning of the semester, the project leader is usually the supervisor of the final thesis. Tasks include e.g. study of literature in the field, mastering the operation of experimental equipment, sample preparation technology, preparation and implementation of the experiment, processing of the obtained data, or collaborating during the preparation of a scientific publication. Credit evaluation takes into account the time requirements of the student when working on a semester project in the range of 150 hours per semester. Individual activities of the student are evaluated by the project leader, the overall work of the student is evaluated by points on a point scale of 0 - 100 points. The minimum threshold for obtaining a rating is 50% of the rating scale, which is determined as follows:

A 100-91%
B 90-81%
C 80-71%
D 70-61%
E 60-50%
Fx 49-0%

Learning outcomes:

After completing the course, the student will acquire knowledge and skills associated with scientific work in the field of condensed matter physics. By actively participating in individual research teams, students will extend their knowledge of physics in the relevant part of condensed matter physics, acquire experimental skills in operating contemporary scientific equipment, study of the literature will improve their language skills. Data processing resp. the creation of original software will improve their computer skills.

Brief outline of the course:

Program for semestral project is prepared individually for each student by supervisor of the project at the beginning of each semester and can be focused on search in literature for a selected area of research, preparation of experiment and its performing, creation of software for data acquisition

and analysis, collaboration during preparation of manuscript, presentation of the obtained results for department audience. Supervisor of the project will specify the topic of the project.

Recommended literature:
Selected scientific journals and books.

Course language:
slovak, english

Notes:
Subject Semester work II is realized in attendance form. If necessary (e.g. Covid pandemic) it is taught online using software MS Teams, which allows to maintain contact with students even in adverse conditions and also allows to meet the requirements of the subject.

Course assessment
Total number of assessed students: 33

A	B	C	D	E	FX
93.94	0.0	6.06	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 24.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ SPFKLc/14	**Course name:** Semestral work III

Course type, scope and the method:
Course type:
Recommended course-load (hours):
Per week: Per study period:
Course method: present

Number of ECTS credits: 6

Recommended semester/trimester of the course: 3.

Course level: II.

Prerequisities: ÚFV/SPFKLb/14

Conditions for course completion:
Successful completing the course, requires the student to demonstrate adequate level of the assigned tasks set by the project leader at the beginning of the semester to the required extent and at the required level. The assignments are formulated by the teacher at the beginning of the semester, the project leader is usually the supervisor of the final thesis. Tasks include e.g. study of literature in the field, mastering the operation of experimental equipment, sample preparation technology, preparation and implementation of the experiment, processing of the obtained data, or collaborating during the preparation of a scientific publication. Credit evaluation takes into account the time requirements of the student when working on a semester project in the range of 150 hours per semester. Individual activities of the student are evaluated by the project leader, the overall work of the student is evaluated by points on a point scale of 0 - 100 points. The minimum threshold for obtaining a rating is 50% of the rating scale, which is determined as follows:
A 100-91%
B 90-81%
C 80-71%
D 70-61%
E 60-50%
Fx 49-0%

Learning outcomes:
After completing the course, the student will acquire knowledge and skills associated with scientific work in the field of condensed matter physics. By actively participating in individual research teams, students will extend their knowledge of physics in the relevant part of condensed matter physics, acquire experimental skills in operating contemporary scientific equipment, study of the literature will improve their language skills. Data processing resp. the creation of original software will improve their computer skills.

Brief outline of the course:
Program for semestral project is prepared individually for each student by supervisor of the project at the beginning of each semester and can be focused on search in literature for a selected area of research, preparation of experiment and its performing, creation of software for data acquisition

and analysis, collaboration during preparation of manuscript, presentation of the obtained results for department audience. Supervisor of the project will specify the topic of the project.

Recommended literature:
Selected scientific journals and books.

Course language:
slovak, english

Notes:
Subject Semester work III is realized in attendance form. If necessary (e.g. Covid pandemic) it is taught online using software MS Teams, which allows to maintain contact with students even in adverse conditions and also allows to meet the requirements of the subject.

Course assessment
Total number of assessed students: 29

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 24.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ OSA1/99	**Course name:** Seminar in Solid State Physics

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 1 **Per study period:** 14
Course method: present

Number of ECTS credits: 1

Recommended semester/trimester of the course: 1.

Course level: II.

Prerequisities:

Conditions for course completion:
Successful completing the course requires the students to participate in the seminars. If serious reasons (disease, family reasons, …) prevent the student to participate in the seminar, students may absent up to twice per semester without further consequences. For more frequent absence student will prepare presentation focused on a topic which will be consulted with the supervisor of the seminar. Student must have adequate knowledge about concepts, phenomena and laws discussed in the presented talks. Preparing a presentation is compulsory, the scope of the presentation is tuned individually according to the topics of the talks and the scope of student‘s diploma thesis. The number of credits participation of the student on the seminar, study of the recommended literature and preparation of the presentation. The level of the presentation is evaluated using scale from 0 to 100 points. The minimum limit for successful completion of the course is to obtain 50 points from the subsequent point evaluation:
Rating scale
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
Successful completing the course deepens knowledge of the student from the area in which student works on the diploma thesis and from other areas of Condensed Matter Physics as well. Student will learn about scientific results of various research group from Košice and from their cooperating foreign institutions. The student is stimulated to participate in scientific discussion an to present own scientific results.

Brief outline of the course:
The program of seminars from condensed matter physics is prepared every year and is devoted to the recent results achieved in the field of condensed matter physics and material research at the laboratories in Košice and abroad. Scientific workers from laboratories from Košice as well

as domestic and foreign guests give the talks. The program also involves presentation of PhD and diploma theses.

Recommended literature:
Scientific papers, which are specified according to the scope of work of a student.

Course language:
slovak, english

Notes:
Presence form represents a standard form for the course, if a need arises, the course is performed using MS Teams.

Course assessment
Total number of assessed students: 52

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 18.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ OSB1/99	**Course name:** Seminar in Solid State Physics

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 1 **Per study period:** 14
Course method: present

Number of ECTS credits: 1

Recommended semester/trimester of the course: 2.

Course level: II.

Prerequisities:

Conditions for course completion:
Successful completing the course requires the students to participate in the seminars. If serious reasons (disease, family reasons, …) prevent the student to participate in the seminar, students may absent up to twice per semester without further consequences. For more frequent absence student will prepare presentation focused on a topic which will be consulted with the supervisor of the seminar. Student must have adequate knowledge about concepts, phenomena and laws discussed in the presented talks. Preparing a presentation is compulsory, the scope of the presentation is tuned individually according to the topics of the talks and the scope of student‘s diploma thesis. The number of credits participation of the student on the seminar, study of the recommended literature and preparation of the presentation. The level of the presentation is evaluated using scale from 0 to 100 points. The minimum limit for successful completion of the course is to obtain 50 points from the subsequent point evaluation:
Rating scale
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
Successful completing the course deepens knowledge of the student from the area in which student works on the diploma thesis and from other areas of Condensed Matter Physics as well. Student will learn about scientific results of various research group from Košice and from their cooperating foreign institutions. The student is stimulated to participate in scientific discussion an to present own scientific results.

Brief outline of the course:
The program of seminars from condensed matter physics is prepared every year and is devoted to the recent results achieved in the field of condensed matter physics and material research at the laboratories in Košice and abroad. Scientific workers from laboratories from Košice as well

as domestic and foreign guests give the talks. The program also involves presentation of PhD and diploma theses.

Recommended literature:
Scientific papers, which are specified according to the scope of work of a student.

Course language:
slovak, english

Notes:
Presence form represents a standard form for the course, if a need arises, the course is performed using MS Teams.

Course assessment
Total number of assessed students: 51

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 18.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ OSC1/99	**Course name:** Seminar in Solid State Physics

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 1 **Per study period:** 14
Course method: present

Number of ECTS credits: 1

Recommended semester/trimester of the course: 3.

Course level: II.

Prerequisities:

Conditions for course completion:
Successful completing the course requires the students to participate in the seminars. If serious reasons (disease, family reasons, …) prevent the student to participate in the seminar, students may absent up to twice per semester without further consequences. For more frequent absence student will prepare presentation focused on a topic which will be consulted with the supervisor of the seminar. Student must have adequate knowledge about concepts, phenomena and laws discussed in the presented talks. Preparing a presentation is compulsory, the scope of the presentation is tuned individually according to the topics of the talks and the scope of student‘s diploma thesis. The number of credits participation of the student on the seminar, study of the recommended literature and preparation of the presentation. The level of the presentation is evaluated using scale from 0 to 100 points. The minimum limit for successful completion of the course is to obtain 50 points from the subsequent point evaluation:
Rating scale
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
Successful completing the course deepens knowledge of the student from the area in which student works on the diploma thesis and from other areas of Condensed Matter Physics as well. Student will learn about scientific results of various research group from Košice and from their cooperating foreign institutions. The student is stimulated to participate in scientific discussion an to present own scientific results.

Brief outline of the course:
The program of seminars from condensed matter physics is prepared every year and is devoted to the recent results achieved in the field of condensed matter physics and material research at the laboratories in Košice and abroad. Scientific workers from laboratories from Košice as well

as domestic and foreign guests give the talks. The program also involves presentation of PhD and diploma theses.

Recommended literature:
Scientific papers, which are specified according to the scope of work of a student.

Course language:
slovak, english

Notes:
Presence form represents a standard form for the course, if a need arises, the course is performed using MS Teams.

Course assessment
Total number of assessed students: 50

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 18.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ OSD1/99	**Course name:** Seminar in Solid State Physics

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 1 **Per study period:** 14
Course method: present

Number of ECTS credits: 1

Recommended semester/trimester of the course: 4.

Course level: II.

Prerequisities:

Conditions for course completion:
Successful completing the course requires the students to participate in the seminars. If serious reasons (disease, family reasons, …) prevent the student to participate in the seminar, students may absent up to twice per semester without further consequences. For more frequent absence student will prepare presentation focused on a topic which will be consulted with the supervisor of the seminar. Student must have adequate knowledge about concepts, phenomena and laws discussed in the presented talks. Preparing a presentation is compulsory, the presentation is devoted to diploma thesis. Student, using the presentation, must give a talk at the seminar, duration of the talk is 20 min. The number of credits takes into account participation of the student on the seminar, study of the recommended literature, preparation of the presentation and the talk. The level of both, the presentation and talk, is evaluated using scale from 0 to 100 points. The minimum limit for successful completion of the course is to obtain 50 points from the subsequent point evaluation:
Rating scale
A 100-91
B 90-81
C 80-71
D 70-61
E 60-50
Fx 49-0

Learning outcomes:
Successful completing the course deepens knowledge of the student from the area in which student works on the diploma thesis and from other areas of Condensed Matter Physics as well. Student will learn about scientific results of various research group from Košice and from their cooperating foreign institutions. The student is stimulated to participate in scientific discussion an to present own scientific results.

Brief outline of the course:
The program of seminars from condensed matter physics is prepared every year and is devoted to the recent results achieved in the field of condensed matter physics and material research at the laboratories in Košice and abroad. Scientific workers from laboratories from Košice as well

as domestic and foreign guests give the talks. The program also involves presentation of PhD and diploma theses.

Recommended literature:
Scientific papers, which are specified according to the scope of work of a student.

Course language:
Slovak, English

Notes:
Presence form represents a standard form for the course, if a need arises, the course is performed using MS Teams.

Course assessment
Total number of assessed students: 51

A	B	C	D	E	FX
100.0	0.0	0.0	0.0	0.0	0.0

Provides: prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 18.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ SAA/18	**Course name:** Sensors and actuators based on selected physical phenomena

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 1 **Per study period:** 14
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course: 2., 4.

Course level: II., III.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient knowledge of the basics of sensors and actuators operating on the basis of physical phenomena with emphasis on basic concepts, properties and parameters of sensors and actuators, static sensor parameters, transmission characteristics and calibration, accuracy, sensitivity, resolution, selectivity, working range, hysteresis and dynamic parameters. Basic physical phenomena used in microsensors such as piezoelectric effect, piezoresistive effect, magnetoresistance effect, Hall effect, Seebeck effect, Peltier effect, magnetostrictive effect, electrostrictive effect, pyroelectric effect. Description of the principle of operation of sensors and actuators based on mechanical, thermal, magnetic, and biochemical domains.
The credit evaluation of the course takes into account the following student workload:
1 credits: direct teaching and self-study of recommended supplementary literature,
1 credit: independent preparation for the final test and its successful completion.
The minimum threshold for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).

Learning outcomes:
After completing the lectures and successfully passing the final test, the student will demonstrate the knowlage of the standard content of the course, which is defined by the brief content of the course and the recommended literature. The result of education is:
a) Creation of the necessary terminology and knowledge base for understanding the operation of sensors and actuators based on selected physical phenomena.
b) Supplementation and summarization of knowledge in the field of physical phenomena and materials with the possibility of use in sensors and actuators.
c) Possibilities of using sensors and actuators in practice.

Brief outline of the course:
Sensors and actuators - introductory terms and definitions. Properties and parameters of sensors and actuators. Basic physical phenomena used in sensors and actuators. Sensors - basic terms and definitions. Mechanical domain based sensors. Thermal domain based sensors. Magnetic domain based sensors. Radiation sensors. Chemical sensors. Tactile sensors. Actuators - basic concepts

and classification. Electrostatic actuators. Piezoelectric actuators. Actuators based on magnetic principles. Thermal actuators. Optical actuators. Mechanical actuators. Chemical actuators.

Recommended literature:

1. 1. M. Husák, Mikrosenzory a mikroaktuátory, Nakladatelství Academia, Praha, (2008)
2. S. Chikazumi, Physics of Ferromagnetism, Oxford University Press, USA (2009)
3. S. Tumanski, Handbook of Magnetic Measurements, CRC Press (2011)
4. N. A. Spaldin, Magnetic Materials: Fundamentals and Device Applications, Cambridge University Press (2003)

Course language:
slovak, english

Notes:
Lectures can be done at presence form or online form using MS Teams. Education form is updated at the begining of the subject

Course assessment
Total number of assessed students: 6

A	B	C	D	E	FX	N	P
16.67	0.0	0.0	0.0	0.0	0.0	0.0	83.33

Provides: prof. RNDr. Rastislav Varga, DrSc., RNDr. Ladislav Galdun, PhD.

Date of last modification: 27.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ SPE1/03	**Course name:** Solid State Spectroscopy
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 3 / 1 **Per study period:** 42 / 14 **Course method:** present	
Number of ECTS credits: 5	
Recommended semester/trimester of the course: 3.	
Course level: II.	
Prerequisities:	

Conditions for course completion:

Continuous active acquisition of the subject is required during the course of Solid State Spectroscopy, which is necessary for independent mastery of individual tasks in self-study and in solving specific homework assignments. During the semester, the student elaborates at least one individual project based on the study of foreign journal literature and the Internet (e.g. a more detailed study of the corresponding physical phenomenon related to the method and its practical applications). Another condition for completing the course is active participation in lectures and exercises. In the exercises, the student will get a concrete idea of how the individual spectrometers work and how the individual spectra are analyzed. Subsequently, the student independently analyzes the experimental data of the selected compound in one or two home projects and presents the results of the analysis at a joint meeting. Another condition for obtaining credits is successful completion of the exam from the theoretical part in the form of an extensive oral discussion, where the student demonstrates an understanding of basic concepts and relationships between them. The minimum threshold for completing the course is successful completion of self-study projects and individual assignments during the semester and mastering the final oral exam from each block (infrared spectroscopy, electron paramagnetic resonance and nuclear magnetic resonance) to more than 50 percent.

Learning outcomes:

After completing the course, the students will gain a basic knowledge, which will allow them to sufficiently orient themselves in the current scientific literature focused on the study of lattice and spin dynamics. This area is currently very topical, especially given the current developments in the field of quantum technologies, where the use of NMR and EPR techniques is expected. It is also very important to know the information on the vibration lattice modes and their effect on q-bit stability, which can be provided, among other things, by infrared and Raman spectroscopy.

Brief outline of the course:

Dr. N. Tomašovičová (part 1-4), Doc. A. Orendáčová (part 5-8), Doc. M. Vilková (part 9-12)

1. Introduction to infrared and Raman spectroscopy. Electromagnetic radiation, energy of a harmonic oscillator from the point of view of classical and quantum physics.
2. Selection rules of vibration transitions. Anharmonic oscillator. Vibration spectra, types of vibrations.

3. Infrared spectrometers - techniques for measuring the infrared and Raman spectra, sample preparation, spectrum analysis - chemical bonds, molecular vibration distribution, identification of the infrared spectrum, interaction with electrons. Infrared microscope.
4. Exercise - practical demonstration of individual measurement techniques (laboratory).
5. Basic characteristics of atomic nuclei and electrons: spin, magnetic moment. The electron shell of an atom. Term. Multiplet. Interaction of an electron shell with a static magnetic and crystal field. Dipole and exchange interaction.
6. Spin Hamiltonian. g-factor anisotropy. Splitting of spin levels in a crystal field. Interaction of an electron shell with oscilating magnetic field. Electron paramagnetic resonance conditions. EPR spectrum of a two-level spin system. Spin-spin, spin-lattice relaxation.
7. Hyperfine structure. Analysis of powder spectra. g-marker. Study of spin dynamics in systems with short-range order. Systems with long-range order. Ferromagnetic resonance, antiferromagnetic resonance.
8. EPR technique. Demonstration of measurements on an EPR spectrometer in the low temperature laboratory of the Institute of Physics PF UPJŠ. Analysis of obtained spectra.
9. One-dimensional (1D) 1 H NMR liquid spectroscopy. Physical nature. Chemical shift 1H and its dependence on external and internal influences. 1H chemical shifts. Spin-spin interaction. Interaction constants and their dependence on structure. Relaxation and line width. Spectrum order and spin systems. Chemical exchange. Spectrum simplification, deuteration, decoupling. Experimental technique for measuring NMR spectra (CW, FT). NMR spectrometers. Dynamic NMR spectroscopy (D NMR).
10. 1D 13C NMR spectroscopy of liquids. Measurement techniques, basic pulse sequences, decoupling, instrumentation. Chemical shifts 13C, their dependence on structure. Spin-spin interaction and interaction constants with the 13C nucleus.
11. 2D NMR spectroscopy. Principles, measurement techniques, pulse sequences. Spectrum presentation. Correlated 2D NMR spectra: H, H-COZY, TOCSY, INADEQUATE, H, C-COZY, HMQC, HSQC, HMBC, NOESY, EXSY, ROESY. J-Resolved 2D NMR homonuclear and heteronuclear spectra. Combined application of spectral methods.
12. Magnetic resonance in biophysics, biochemistry and medicine. NMR spectroscopy of other nuclei (2H, 15N, 29P, 19F, 11B and others). Solid phase NMR. Wide-line spectra. High resolution solid state NMR. NMR ferromagnets. Work on a professional NMR spectrometer in the laboratory of the Institute of Chemical Sciences PF UPJŠ. Analysis of obtained spectra.

Recommended literature:

1. G. Schatz a A. Weidinger: Nuclear Condensed Matter Physics, Nuclear methods and applications, Wiley, 1996.
2. Slichter C. P.: Principles of Magnetic Resonance, Springer-Verlag, London, 1990.
3. P. Brüesch, Photons: Theory and Experiments II, 65 Springer Series in Solid-State Sciences Edited by P. Fulde, Springer-Verlag Berlin Heidelberg 1986.
4. A. Abragam, B. Bleaney, Electron Paramagnetic Resonance of Transition Ions, Oxford, 2012.

Course language:

english

Notes:

The course Solid State Spectroscopy is realized in the attendance form. In some special cases (as was pandemics of Covid) the teaching is realized online using software MS Teams, which enables to keep the contact with students and to keep the level and quality of the course.

Course assessment
Total number of assessed students: 45

A	B	C	D	E	FX
57.78	20.0	11.11	8.89	2.22	0.0

Provides: doc. RNDr. Alžbeta Orendáčová, DrSc., RNDr. Natália Tomašovičová, CSc., doc. RNDr. Mária Vilková, PhD.

Date of last modification: 19.09.2022

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/SPR1/00	**Course name:** Special Practical Exercises I
Course type, scope and the method: **Course type:** Practice **Recommended course-load (hours):** **Per week:** 3 **Per study period:** 42 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 1.	
Course level: II.	
Prerequisities:	
Conditions for course completion: To successfully complete the course, the student must complete all experimental tasks set by the course syllabus and evaluate the experimental results in the form of a protocol. The condition for the implementation of the practical task is sufficient theoretical training at home. The credit evaluation of the course takes into account the following student workload: 1 credit: self-study of recommended literature and subsequent direct teaching 1 credits: realization of experimental exercise and subsequent defense of measuring procedure 1 credit: elaboration and submission of protocols from measurements that are evaluated.	
Learning outcomes: The result of education is: 1) Acquisition of basic abilities and skills in the experimental investigation of selected phenomena in the field of magnetic and structural properties of materials. 2) Analysis and interpretation of results and experience in preparing the protocols on measurement and measurement results.	
Brief outline of the course: Measurement of electrical resistivity (S. Dobák). Measurement of initial magnetization curves and hysteresis loops in quasi-static and dynamic regime (S. Dobák). Measurement of complex permeability spectra (S. Dobák). Observation of the domain structure of ferromagnets by colloidal technique using an optical microscope. (A. Zeleňáková) Observation of the domain structure of ferromagnets by the MFM method. (A. Zeleňáková) Measurement of temperature and field dependence of magnetization of magnetic substances using MPMS device based on SQUID. (A. Zeleňáková) Magnetoimpedance measurement. (L. Galdun) Measurement of domain wall dynamics (L. Galdun) Magneto-optical measurements using the Kerr effect. (L. Galdun) Study of atomic structure using powder XRD (J. Bednarčík) Study of atomic structure using single crystal XRD diffraction (J. Bednarčík) Study of structural substances using SAXS (J. Bednarčík)	

Recommended literature:
Tumanski S, Handbook of magnetic measurements, CRC press, 2011.
Fiorillo F, Characterization and Measurement of Magnetic Materials, Elsevier, 2004.
Dufek M., Hrabák J., Trnaka Z.: Magnetická měření, SNTL, 1964, Praha
Brož J. a kol.: Základy fysikálnich měření, SPN, 1974, Praha.

Course language:
Slovak or English

Notes:
Teaching is carried out in person. If necessary, part of the teaching can be realized remotely using the MS Teams or BBB tool. The form of teaching will be specified by the teacher at the beginning of the semester, it is continuously updated.

Course assessment
Total number of assessed students: 34

A	B	C	D	E	FX	N	P
100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Provides: RNDr. Jozef Bednarčík, PhD., univerzitný docent, doc. RNDr. Adriana Zeleňáková, PhD., doc. RNDr. Ján Füzer, PhD.

Date of last modification: 01.10.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ SPR2/09	**Course name:** Special Practicum II
Course type, scope and the method: **Course type:** Practice **Recommended course-load (hours):** **Per week:** 3 **Per study period:** 42 **Course method:** present	
Number of ECTS credits: 4	
Recommended semester/trimester of the course: 2.	
Course level: II.	
Prerequisities:	
Conditions for course completion: Successful completing the course requires the students to demonstrate sufficient knowledge and skills in experimental study of selected properties of solids at predominantly low temperatures. The number of credits takes into account participation of the student on the laboratory exercises (2 credits), study of the recommended literature (1 credit), and preparation of the reports (1 credit). Activity and skills in participating experiments and the level of report which should contain theoretical background, discussion how formulated goals were met and/or acquisition of the experimental data are evaluated. Submitting all reports represent necessary condition for passing the course. Activity of the student during conducting experiments is evaluated in range 0 – 25 points. Quality of the report is evaluated using the scale 0 – 100 points. The minimum limit for successful completion of the course is to obtain 50 points in total from the subsequent point evaluation: Rating scale A 100-91 B 90-81 C 80-71 D 70-61 E 60-50 Fx 49-0	
Learning outcomes: Obtaining fundamental theoretical, experimental skills and ability to analyze the obtained experimental data in selected areas of physical research in condensed matter, primarily at low temperatures.	
Brief outline of the course: Exercises n. 1. – 6. are given by prof. Ing. M. Orendáč, DrSc., exercises n. 7. – 12. are given by doc. RNDr. E. Čižmár, PhD. 1.Calibration of resistance thermometers. Choice of a function for the analysis of the calibration curve, determination of the degree of the fitting polynom. Analysis of the temperature dependence of the relative deviation.	

2. Determination of the magnitude of the spin from calorimetric data. Determination of the molar specific heat. Standard extrapolations for the calulation of the magnetic entropy at low and high temperatures. Calculation of contributions to magnetic entropy.
3. Magnetocaloric effect. Calculation of the temperature dependence of the isothermal change of magnetic entropy from calorimetric data. Comparisson of the data for quantum spin chain and S=1/2 paramagnet.
4. Study of spin dynamics from the data of alternating susceptibility. Cole – Cole diagram and its construction. Width of the distribution of relaxation times. Temperature dependence of relaxation processes in a selected model system.
5. Study of critical behavior from calorimetric data. Analysis of the specific heat data in a critical region for different magnetic fields. Critical indexes, their dependence on external magnetic field. Comparisson of the values of critical indexes with predictions from selected models.
6. Experimental study of spin-glass state. Analysis of static magnetic susceptibility data obtained in "zero-field cooled" and "field-cooled" regimes. Study of the influence of external magnetic field. Analysis of alternating susceptibility data obtained at various temperatures. Study of the effect of the excitation frequency. Construction of Cole-Cole diagrams.
7. Vacuum technique. Methods of leak detection in vacuum systems.
8. Preparation of the samples. Specific heat measurements in cryogenic devices. Analysis and intrepretation of the experimental results.
9. Susceptibility and magnetization of magnetic systems. Preparation of the sample, setting sequence of measurement for SQUID magnetometer.
10. Analysis of the experimental data of magnetization and susceptibility (Curie – Weiss law, Brillouin function, determination of the nature of exchange coupling)
11. Electron paramagnetic resonance in magnetic systems. Preparation of the sample, collection of the data. Analysis of the obtained data (Determination of the anisotropy of g-factor, analysis of the resonance linewidth)
12. Electrical resistivity in normal metals and superconductors. Preparation of the sample, setting sequence of measurement for PPMS device. Analysis of the obtained data (determination of RRR, residual resistivity, critical temperature of a superconductor).

Recommended literature:

J. H. Moore and N. D. Spencer: Encyclopedia o Chemical Physics and Physical Chemistry Vol. I., II. and III., IoP Publishing Ltd. 2001, ISBN 0750303131.
Selected scientific publications.
F. Pobell, Methods and Matter at Low Temperatures, Springer Verlag, Berlin Heidelberg, 1992.
J. A. Mydosh, Spin glasses: An Experimental Introduction, Taylor&Francis, 1993.

Course language:

Slovak, English

Notes:

Presence form represents a standard form for the course, if a need arises, the course can be partially performed using MS Teams.

Course assessment

Total number of assessed students: 33

A	B	C	D	E	FX	N	P
69.7	12.12	9.09	0.0	0.0	0.0	0.0	9.09

Provides: doc. RNDr. Erik Čižmár, PhD., prof. Ing. Martin Orendáč, DrSc.

Date of last modification: 22.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚTVŠ/TVa/11	**Course name:** Sports Activities I.

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course: 1.

Course level: I., II.

Prerequisities:

Conditions for course completion:
Min. 80% of active participation in classes.

Learning outcomes:
Sports activities in all their forms prepare university students for their professional and personal life. They have a great impact on physical fitness and performance. Specialization in sports activities enables students to strengthen their relationship towards the selected sport in which they also improve.

Brief outline of the course:
Brief outline of the course:
The Institute of physical education and sport at the Pavol Jozef Šafárik University offers 20 sports activities aerobics; aikido, basketball, badminton, body-balance, body form, bouldering, floorball, yoga, power yoga, pilates, swimming, fitness, indoor football, SM system, step aerobics, table tennis, chess, volleyball, tabata, cycling.
Additionally, the Institute of physical education and sport at the Pavol Jozef Šafárik University offers winter courses (ski course, survival) and summer courses (aerobics by the sea, rafting on the Tisza River) with an attractive programme, sports competitions with national and international participation.

Recommended literature:

BENCE, M. et al. 2005. Plávanie. Banská Bystrica: FHV UMB. 198s. ISBN 80-8083-140-8. [online] Dostupné na: https://www.ff.umb.sk/app/cmsFile.php?disposition=a&ID=571
BUZKOVÁ, K. 2006. Fitness jóga, harmonické cvičení těla I duše. Praha: Grada. ISBN 8024715252.
JARKOVSKÁ, H, JARKOVSKÁ, M. 2005. Posilování s vlastním tělem 417 krát jinak. Praha: Grada. ISBN 9788024757308.
KAČÁNI, L. 2002. Futbal:Tréning hrou. Bratislava: Peter Mačura – PEEM. 278s. ISBN 8089197027.
KRESTA, J. 2009. Futsal.Praha: Grada Publishing, a.s. 112s. ISBN 9788024725345.
LAWRENCE, G. 2019. Power jóga nejen pro sportovce. Brno: CPress. ISBN 9788026427902.
SNER, Wolfgang. 2004. Posilování ve fitness. České Budějovice: Kopp. ISBN 8072322141.

STACKEOVÁ, D. 2014. Fitness programy z pohledu kinantropologie. Praha: Galén. ISBN 9788074921155.
VOMÁČKO, S. BOŠTÍKOVÁ, S. 2003. Lezení na umělých stěnách. Praha: Grada. 129s. ISBN 8024721743.

Course language:
Slovak language

Notes:

Course assessment
Total number of assessed students: 15193

abs	abs-A	abs-B	abs-C	abs-D	abs-E	n	neabs
86.05	0.07	0.0	0.0	0.0	0.05	8.69	5.15

Provides: Mgr. Patrik Berta, Mgr. Agata Dorota Horbacz, PhD., Mgr. Dávid Kaško, PhD., Mgr. Ladislav Kručanica, PhD., Mgr. Richard Melichar, Mgr. Petra Tomková, PhD., Mgr. Marcel Čurgali, Mgr. Alena Buková, PhD., doc. PaedDr. Ivan Uher, MPH, PhD., prof. RNDr. Stanislav Vokál, DrSc., Mgr. Zuzana Küchelová, PhD.

Date of last modification: 07.02.2024

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚTVŠ/ TVb/11	**Course name:** Sports Activities II.

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course: 2.

Course level: I., II.

Prerequisities:

Conditions for course completion:
active participation in classes - min. 80%.

Learning outcomes:
Sports activities in all their forms prepare university students for their professional and personal life. They have a great impact on physical fitness and performance. Specialization in sports activities enables students to strengthen their relationship towards the selected sport in which they also improve.

Brief outline of the course:
Brief outline of the course:
The Institute of physical education and sport at the Pavol Jozef Šafárik University offers 20 sports activities aerobics; aikido, basketball, badminton, body-balance, body form, bouldering, floorball, yoga, power yoga, pilates, swimming, fitness, indoor football, SM system, step aerobics, table tennis, chess, volleyball, tabata, cycling.
Additionally, the Institute of physical education and sport at the Pavol Jozef Šafárik University offers winter courses (ski course, survival) and summer courses (aerobics by the sea, rafting on the Tisza River) with an attractive programme, sports competitions with national and international participation.

Recommended literature:

BENCE, M. et al. 2005. Plávanie. Banská Bystrica: FHV UMB. 198s. ISBN 80-8083-140-8. [online] Dostupné na: https://www.ff.umb.sk/app/cmsFile.php?disposition=a&ID=571
BUZKOVÁ, K. 2006. Fitness jóga, harmonické cvičení těla I duše. Praha: Grada. ISBN 8024715252.
JARKOVSKÁ, H, JARKOVSKÁ, M. 2005. Posilování s vlastním tělem 417 krát jinak. Praha: Grada. ISBN 9788024757308.
KAČÁNI, L. 2002. Futbal:Tréning hrou. Bratislava: Peter Mačura – PEEM. 278s. ISBN 8089197027.
KRESTA, J. 2009. Futsal.Praha: Grada Publishing, a.s. 112s. ISBN 9788024725345.
LAWRENCE, G. 2019. Power jóga nejen pro sportovce. Brno: CPress. ISBN 9788026427902.
SNER, Wolfgang. 2004. Posilování ve fitness. České Budějovice: Kopp. ISBN 8072322141.

STACKEOVÁ, D. 2014. Fitness programy z pohledu kinantropologie. Praha: Galén. ISBN 9788074921155.
VOMÁČKO, S. BOŠTÍKOVÁ, S. 2003. Lezení na umělých stěnách. Praha: Grada. 129s. ISBN 8024721743.

Course language:
Slovak language

Notes:

Course assessment
Total number of assessed students: 13318

abs	abs-A	abs-B	abs-C	abs-D	abs-E	n	neabs
84.37	0.51	0.02	0.0	0.0	0.05	10.78	4.28

Provides: Mgr. Agata Dorota Horbacz, PhD., Mgr. Dávid Kaško, PhD., Mgr. Marcel Čurgali, Mgr. Patrik Berta, Mgr. Ladislav Kručanica, PhD., Mgr. Richard Melichar, Mgr. Petra Tomková, PhD., Mgr. Alena Buková, PhD., doc. PaedDr. Ivan Uher, MPH, PhD., prof. RNDr. Stanislav Vokál, DrSc., Mgr. Zuzana Küchelová, PhD.

Date of last modification: 07.02.2024

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚTVŠ/ TVc/11	**Course name:** Sports Activities III.
Course type, scope and the method: **Course type:** Practice **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course: 3.	
Course level: I., II.	
Prerequisities:	
Conditions for course completion: min. 80% of active participation in classes	
Learning outcomes: Sports activities in all their forms prepare university students for their professional and personal life. They have a great impact on physical fitness and performance. Specialization in sports activities enables students to strengthen their relationship towards the selected sport in which they also improve.	
Brief outline of the course: Brief outline of the course: The Institute of physical education and sport at the Pavol Jozef Šafárik University offers 20 sports activities aerobics; aikido, basketball, badminton, body-balance, body form, bouldering, floorball, yoga, power yoga, pilates, swimming, fitness, indoor football, SM system, step aerobics, table tennis, chess, volleyball, tabata, cycling. Additionally, the Institute of physical education and sport at the Pavol Jozef Šafárik University offers winter courses (ski course, survival) and summer courses (aerobics by the sea, rafting on the Tisza River) with an attractive programme, sports competitions with national and international participation.	
Recommended literature: BENCE, M. et al. 2005. Plávanie. Banská Bystrica: FHV UMB. 198s. ISBN 80-8083-140-8. [online] Dostupné na: https://www.ff.umb.sk/app/cmsFile.php?disposition=a&ID=571 BUZKOVÁ, K. 2006. Fitness jóga, harmonické cvičení těla I duše. Praha: Grada. ISBN 8024715252. JARKOVSKÁ, H, JARKOVSKÁ, M. 2005. Posilování s vlastním tělem 417 krát jinak. Praha: Grada. ISBN 9788024757308. KAČÁNI, L. 2002. Futbal:Tréning hrou. Bratislava: Peter Mačura – PEEM. 278s. ISBN 8089197027. KRESTA, J. 2009. Futsal.Praha: Grada Publishing, a.s. 112s. ISBN 9788024725345. LAWRENCE, G. 2019. Power jóga nejen pro sportovce. Brno: CPress. ISBN 9788026427902. SNER, Wolfgang. 2004. Posilování ve fitness. České Budějovice: Kopp. ISBN 8072322141.	

STACKEOVÁ, D. 2014. Fitness programy z pohledu kinantropologie. Praha: Galén. ISBN 9788074921155.
VOMÁČKO, S. BOŠTÍKOVÁ, S. 2003. Lezení na umělých stěnách. Praha: Grada. 129s. ISBN 8024721743.

Course language:
Slovak language

Notes:

Course assessment
Total number of assessed students: 9100

abs	abs-A	abs-B	abs-C	abs-D	abs-E	n	neabs
88.37	0.07	0.01	0.0	0.0	0.02	4.46	7.07

Provides: Mgr. Marcel Čurgali, Mgr. Agata Dorota Horbacz, PhD., Mgr. Dávid Kaško, PhD., Mgr. Patrik Berta, Mgr. Ladislav Kručanica, PhD., Mgr. Richard Melichar, Mgr. Petra Tomková, PhD., Mgr. Alena Buková, PhD., doc. PaedDr. Ivan Uher, MPH, PhD., prof. RNDr. Stanislav Vokál, DrSc., Mgr. Zuzana Küchelová, PhD.

Date of last modification: 07.02.2024

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚTVŠ/ TVd/11	**Course name:** Sports Activities IV.
Course type, scope and the method: **Course type:** Practice **Recommended course-load (hours):** **Per week:** 2 **Per study period:** 28 **Course method:** present	
Number of ECTS credits: 2	
Recommended semester/trimester of the course: 4.	
Course level: I., II.	
Prerequisities:	
Conditions for course completion: min. 80% of active participation in classes	
Learning outcomes: Sports activities in all their forms prepare university students for their professional and personal life. They have a great impact on physical fitness and performance. Specialization in sports activities enables students to strengthen their relationship towards the selected sport in which they also improve.	
Brief outline of the course: Brief outline of the course: The Institute of physical education and sport at the Pavol Jozef Šafárik University offers 20 sports activities aerobics; aikido, basketball, badminton, body-balance, body form, bouldering, floorball, yoga, power yoga, pilates, swimming, fitness, indoor football, SM system, step aerobics, table tennis, chess, volleyball, tabata, cycling. Additionally, the Institute of physical education and sport at the Pavol Jozef Šafárik University offers winter courses (ski course, survival) and summer courses (aerobics by the sea, rafting on the Tisza River) with an attractive programme, sports competitions with national and international participation.	
Recommended literature: BENCE, M. et al. 2005. Plávanie. Banská Bystrica: FHV UMB. 198s. ISBN 80-8083-140-8. [online] Dostupné na: https://www.ff.umb.sk/app/cmsFile.php?disposition=a&ID=571 BUZKOVÁ, K. 2006. Fitness jóga, harmonické cvičení těla I duše. Praha: Grada. ISBN 8024715252. JARKOVSKÁ, H, JARKOVSKÁ, M. 2005. Posilování s vlastním tělem 417 krát jinak. Praha: Grada. ISBN 9788024757308. KAČÁNI, L. 2002. Futbal:Tréning hrou. Bratislava: Peter Mačura – PEEM. 278s. ISBN 8089197027. KRESTA, J. 2009. Futsal.Praha: Grada Publishing, a.s. 112s. ISBN 9788024725345. LAWRENCE, G. 2019. Power jóga nejen pro sportovce. Brno: CPress. ISBN 9788026427902. SNER, Wolfgang. 2004. Posilování ve fitness. České Budějovice: Kopp. ISBN 8072322141.	

STACKEOVÁ, D. 2014. Fitness programy z pohledu kinantropologie. Praha: Galén. ISBN 9788074921155.
VOMÁČKO, S. BOŠTÍKOVÁ, S. 2003. Lezení na umělých stěnách. Praha: Grada. 129s. ISBN 8024721743.

Course language:
Slovak language

Notes:

Course assessment
Total number of assessed students: 5671

abs	abs-A	abs-B	abs-C	abs-D	abs-E	n	neabs
82.81	0.28	0.04	0.0	0.0	0.0	7.97	8.9

Provides: Mgr. Marcel Čurgali, Mgr. Agata Dorota Horbacz, PhD., Mgr. Dávid Kaško, PhD., Mgr. Patrik Berta, Mgr. Ladislav Kručanica, PhD., Mgr. Richard Melichar, Mgr. Petra Tomková, PhD., Mgr. Alena Buková, PhD., doc. PaedDr. Ivan Uher, MPH, PhD., prof. RNDr. Stanislav Vokál, DrSc., Mgr. Zuzana Küchelová, PhD.

Date of last modification: 07.02.2024

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ XRAY/20	**Course name:** Structure characterization by X-ray based techniques
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 2 / 0 **Per study period:** 28 / 0 **Course method:** present	
Number of ECTS credits: 3	
Recommended semester/trimester of the course: 2.	
Course level: II., III.	
Prerequisities:	
Conditions for course completion: To successfully complete the course, student must attend all lectures. In justified cases, two absences are allowed. Furthermore, for successful completion of the course, a written elaboration of the assignment is assumed. The credit evaluation of the course takes into account the following student workload: direct teaching and self-study of recommended literature - 2 credits, elaboration of a written assignment - 1 credit.	
Learning outcomes: To understand basic concepts of the X-ray crystallography and X-ray powder diffraction. Be able to perform phase analysis, refine the value of the lattice constant and estimate the average grain size from raw diffraction data. To understand basic concepts of the synchrotron radiation and its properties. Get familiarized with selected scattering, spectroscopy and imaging techniques utilizing synchrotron radiation.	
Brief outline of the course: X-rays are a unique tool to characterize the atomic and electronic structure of many materials, including periodic/ordered and non-periodic/disordered systems. X-ray diffraction and scattering methods provide structural information of mainly periodic systems down to atomic resolution. The course is divided in two sections. The first part covers basic concepts of the X-ray crystallography and X-ray powder diffraction, which represents one of the most essential tools in the structural characterization of materials. The first part is complemented with a hands-on laboratory section which aims to prepare reader to be able to independently deploy the technique for use in own research. The second part of the course covers basics concepts of the synchrotron radiation. Perspective reader will learn about unique properties of synchrotron radiation and its use in various scattering, spectroscopy and imaging techniques. The layout of typical synchrotron beamline with all essential components (monochromator, mirrors, focusing lenses, slit systems, sample stage and detectors) will be presented. Experimental techniques such as Small Angle X-ray Scattering (SAXS), Pair Distribution Function (PDF), X-ray Absorption Spectroscopy and X-ray Computed Tomography will be introduced in more details. At the end there will be a lesson covering recent development in the emerging field of X-ray Free Electron Lasers (XFELs)	
Recommended literature:	

[1] V. K. Pecharsky and P. Y. Zavalij, „Fundamentals of Powder Diffraction and Structural Characterization of Materials“, Springer, New York, 2005.
[2] D. Attwood and A. Sakdinawat, „X-Rays and Extreme Ultraviolet Radiation: Principles and Applications“, 2nd Edition, Cambridge University Press, 2016.
[3] M. Watanabe, S. Sato, I. Munro and G.S. Lodha, „A Guide to Synchrotron Radiation Science“, Narosa Publishing House. New Delhi, 2016
[4] U. Bergmann, V. K. Yachandra and J. Yano, „ X-Ray Free Electron Lasers: Applications in Materials, Chemistry and Biology“, The Royal Society of Chemistry, London, 2017

Course language:
slovak, english

Notes:
The course will be taught in person or using online communication tools.

Course assessment
Total number of assessed students: 19

abs	n
100.0	0.0

Provides: RNDr. Jozef Bednarčík, PhD., univerzitný docent

Date of last modification: 28.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ SVKK/99	**Course name:** Student Scientific Conference

Course type, scope and the method:
Course type:
Recommended course-load (hours):
Per week: **Per study period:**
Course method: present

Number of ECTS credits: 4

Recommended semester/trimester of the course: 2., 4.

Course level: II.

Prerequisities:

Conditions for course completion:
Research activities of a student during semester.
Presentation of the achieved results at the Scientific Student Conference at the faculty level.

Learning outcomes:
Students will obtain experience with presentation of achieved scientific results.

Brief outline of the course:
As required by individual topics of research.

Recommended literature:
According to requirements of individual topics of student works.

Course language:
slovak, english

Notes:

Course assessment
Total number of assessed students: 4

abs	n
100.0	0.0

Provides: doc. RNDr. Adriana Zeleňáková, PhD.

Date of last modification: 01.12.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚTVŠ/ LKSp/13	**Course name:** Summer Course-Rafting of TISA River

Course type, scope and the method:
Course type: Practice
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 2

Recommended semester/trimester of the course:

Course level: I., II.

Prerequisities:

Conditions for course completion:
Completion: passed
Condition for successful course completion:
- active participation in line with the study rule of procedure and course guidelines
- effective performance of all tasks: carrying a canoe, entering and exiting a canoe, righting a canoe, paddling

Learning outcomes:
Content standard:
The student demonstrates relevant knowledge and skills in the field, which content is defined in the course syllabus and recommended literature.
Performance standard:
Upon completion of the course students are able to meet the performance standard and:
- implement the acquired knowledge in different situations and practice,
- implement basic skills to manipulate a canoe on a waterway,
- determine the right spot for camping,
- prepare a suitable material and equipment for camping.

Brief outline of the course:
Brief outline of the course:
1. Assessment of difficulty of waterways
2. Safety rules for rafting
3. Setting up a crew
4. Practical skills training using an empty canoe
5. Canoe lifting and carrying
6. Putting the canoe in the water without a shore contact
7. Getting in the canoe
8. Exiting the canoe
9. Taking the canoe out of the water
10. Steering
a) The pry stroke (on fast waterways)
b) The draw stroke

11. Capsizing
12. Commands

Recommended literature:
1. JUNGER, J. et al. Turistika a športy v prírode. Prešov: FHPV PU v Prešove. 2002. ISBN 8080680973.
Internetové zdroje:
1. STEJSKAL, T. Vodná turistika. Prešov: PU v Prešove. 1999.
Dostupné na: https://ulozto.sk/tamhle/UkyxQ2lYF8qh/name/Nahrane-7-5-2021-v-14-46-39#!ZGDjBGR2AQtkAzVkAzLkLJWuLwWxZ2ukBRLjnGqSomICMmOyZN==

Course language:
Slovak language

Notes:

Course assessment
Total number of assessed students: 209

abs	n
37.32	62.68

Provides: Mgr. Dávid Kaško, PhD.

Date of last modification: 29.03.2022

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ FPO/14	**Course name:** Surface science

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 1.

Course level: II., III.

Prerequisities:

Conditions for course completion:
To successfully complete the course, the student must demonstrate sufficient understanding of the basic principles in the field of surface physics and superficial science. The credit evaluation of the course takes into account the following student workload: direct teaching 2 credits, final exam 1 credit. The condition for obtaining credits is passing an oral exam on questions within selected topic. The minimum threshold for completing the course is to obtain at least 50% of the total score, using the following rating scale: A (90-100%), B (80-89%), C (70-79%), D (60- 69%), E (50-59%), F (0-49%).

Learning outcomes:
The goal of this course is to introduce student to theory and physical properties of surfaces, processes and phenomena on surfaces and methods used for their study. In the introduction i will make general overview of terminology in physics of surfaces, electronic structure of solids with application to surfaces. I will make detailed overview of experimental methods used for surface characterization. Student will learn about theory of adsorption and diffusion on surfaces, with thermodynamics and kinetics of processes on surfaces and growth of layers. I will show examples of physical and chemical processes on surfaces in real applications. Student will gain basic knowledge about theory of interfaces and about processes stimulated by laser and electrons and about manipulation on surfaces on nanoscale.

Brief outline of the course:
1. Introduction.
2. Electronic structure. Band theory of solids: metals, semiconductors and isolators.
3. Experimental methods to study surfaces.
4. Diffusion on surfaces.
5. Adsorption on surfaces.
6. Thermodynamics and kinetics of adsorption and desorption.
7. Interfaces.
8. Catalytic processes on surfaces.
9. Growth on surfaces and epitaxy.
10. Processes on surfaces simulated by photons and electrons.
11. Electrified interfaces.

12. Manipulation on surfaces.

Recommended literature:

1. K. W. Kolasinski, Surface Science Foundations of Catalysis and Nanoscience, John Wiley and Sons, Ltd. 2008.
2. Ch. Kittel, Introduction to Solid State Physics, 7th edition, John Wiley and Sons, 1995.
3. A. Zangwill Physics at Surfaces, Cambridge university press, 1988

Course language:
slovak, english

Notes:
Teaching is carried out full-time or part-time using the MS teams platform. Form of teaching are specified by the teacher at the beginning of the semester and continuously updated as needed.

Course assessment
Total number of assessed students: 36

A	B	C	D	E	FX	N	P
44.44	27.78	0.0	0.0	0.0	0.0	0.0	27.78

Provides: Mgr. Vladimír Komanický, PhD., univerzitný docent

Date of last modification: 28.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ ZTE/03	**Course name:** Technology of Condensed Maters

Course type, scope and the method:
Course type: Lecture
Recommended course-load (hours):
Per week: 2 **Per study period:** 28
Course method: present

Number of ECTS credits: 3

Recommended semester/trimester of the course: 1.

Course level: II.

Prerequisities:

Conditions for course completion:
30 % maintained output, written test
70% final output, oral exam

Learning outcomes:
The course gives information about principles of solidification, precipitatin. Thermodynamics of phase transitions, Plastic deformation, strethenning and Racrystallisation and Hot working

Brief outline of the course:
Principles of solidification: solidification defects, casting processes for manufacturing components, ingot casting, directional solidification, single crystal growth and epitaxial growth, joining of metallic materials. Solid solutions and phase equilibrium: phase diagrams,solubility and solutions, solid-solution strengthening. Relationship between properties and phase diagram. Nonequiblirium solidificatin and segregation. Dispersion strengthening and eutectic phase diagram: intermetallic compounds, eutectic phase diagram, eutectic alloys. Dispersion strengthening by phase transformations and heat treatment: nucleation and growth in solid-state reactions, precipitation hardening, age hardening, eutectoid reaction – pearlite, bainite and martensitic reaction, Strain hardening snd annealing. Hot working, recrystallisation. Superplastic forming. Ferrous alloys. Amorphou and nanocrystalline materials - preparation and properties

Recommended literature:

1. D.R.Askeland and P.P. Phulé, The Science and Engineering of Materials, Thomson 2003.
2. R.W. Cahn et al, Physical Metalurgy I, Elsevier, 1983, ISBN - 0-444-86786-4
3. R.W. Cahn et al, Physical Metalurgy I, Elsevier, 1983, ISBN - 0-444-86787-2
4.Donald R. Askeland, Pradeep P. Fulay, Wendelin. Wright, The Science and Engineering of Materials, Cengage Learning 2011, sixth edition, www.cengage.com/engineering ISBN 13:978-0-495-29602-7.

Course language:
English

Notes:
Lectures can be done at presence form or online using MS Teams. Education form is updated at the begining of the subject. All ppt presentations are accesible in LMS UPJŠ.

Course assessment
Total number of assessed students: 38

A	B	C	D	E	FX
60.53	36.84	2.63	0.0	0.0	0.0

Provides: prof. RNDr. Pavol Sovák, CSc.

Date of last modification: 29.09.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice	
Faculty: Faculty of Science	
Course ID: ÚFV/ TKL1/99	**Course name:** Theory of Condensed Matter
Course type, scope and the method: **Course type:** Lecture / Practice **Recommended course-load (hours):** **Per week:** 4 / 2 **Per study period:** 56 / 28 **Course method:** present	
Number of ECTS credits: 8	
Recommended semester/trimester of the course: 1.	
Course level: II.	
Prerequisities:	

Conditions for course completion:

1. Attendance at lessons in accordance with the study rules and the teacher's instructions.
2. Activity at exercises.
3. Self-study and submission of independently solved homework.

Conditions for the final evaluation:

1. Final written exam, solving of problems.
2. Final oral exam or multiple choice test.

Conditions for successful completion of the course and obtaining 8 ECTS credits:

1. Participation at lessons in accordance with the study regulations and according to the instructions of the teacher (40% share of ECTS credits).
2. Mastering conditions of continuous assessment of self-study and homeworks at the level in the assessment scale of at least 60% in total (50% share of ECTS credits).
3. Mastering conditions of the final evaluation in the overall expression at the level of at least 20% from solving of problems and an oral exam or test (10% share of ECTS credits).
4. Rating scale: A 100% - 90%, B 89% - 75%, C 74% - 60%, D 59% - 40%, E 39% - 20%, FX 19% - 0.

Learning outcomes:

The graduate of the course will master basic concepts of the condensed matter structure and acquire knowledge of derivation their properties from the quantum nature of electrons, phonons, photons, magnons and their mutual interactions, which are modulated by the periodic arrangement of atoms. The graduate will learn the quasiparticle formalism in order to the describe electrical properties, optical properties, superconductivity, and will be able to calculate dispersions of quasiparticles and deduce basic properties of the condensed matter. The graduate will acquire sufficient physical and mathematical knowledge to independently solve current scientific problems in the physics of condensed matter and in the study of material properties.

Brief outline of the course:

1. Theoretical description of solid state structure. Electrons in periodic lattice, Bloch's theorem, reciprocal lattice and Brillouin zone, Born-von Karmán periodic boundary conditions.
2. Velocity of Bloch states, density of states, approximation of nearly-free electrons.
3. Band structure. Tight-binding method.

4. k.p method and Wannier functions.
5. Electrons in magnetic field. Properties of materials, heat capacity and susceptibility.
6. Lattice vibrations in harmonic approximation, thermodynamics of crystal solids.
7. Quantum theory of lattice vibration in solids, phonons.
8. Optical properties of solids, dielectric function, optical conductivity, excitons.
9. Superconductivity, electron-phonon effective attractive interaction.
10. Cooper pairs, BCS theory. Ground and excited state of superconductor.
11. Magnetism in solids, itinerant and localized ferromagnetism, Laudau diamagnetism.
12. Magnons and spin waves in insulators, thermodynamics of magnons. Spin dynamics.

Recommended literature:

Simon, S. H. The Oxford Solid State Basics. Oxford University Press, 2013.
Girvin, S. M., Yang, K. Modern Condensed Matter Physics. Cambridge University Press, 2019.
Cohen, M. L., Louie, S. G. Fundamentals of Condensed Matter Physics. Cambridge University Press, 2016.
Ketterson, J. B. The Physics of Solids. Oxford University Press, 2016.
Kaxiras, E. Atomic and Electronic Struture of Solids, Cambridge University Press, 2003.
Ashcroft, N. W., Mermin, N. D. Solid State Physics. Harcourt College Publishers, 1976.

Course language:

Notes:

The course is implemented in a full-time form, if necessary remotely in the MS Teams environment.

Course assessment

Total number of assessed students: 110

A	B	C	D	E	FX
51.82	14.55	17.27	7.27	9.09	0.0

Provides: RNDr. Martin Gmitra, PhD.

Date of last modification: 18.11.2021

Approved: prof. Ing. Martin Orendáč, DrSc.

COURSE INFORMATION LETTER

University: P. J. Šafárik University in Košice

Faculty: Faculty of Science

Course ID: ÚFV/ TRANS/18	**Course name:** Transport properties of solids

Course type, scope and the method:
Course type: Lecture / Practice
Recommended course-load (hours):
Per week: 2 / 1 **Per study period:** 28 / 14
Course method: present

Number of ECTS credits: 4

Recommended semester/trimester of the course: 2., 4.

Course level: II.

Prerequisities:

Conditions for course completion:
During the continuous and final assessment, the student will demonstrate adequate mastery of the course content standard and a sufficient level of understanding of the topics covered in the course outline. The basis of the mid-term evaluation is active participation in the class and submission of independently solved homework assignments at the overall level of 50% correct solutions for the entire semester. A condition for successful completion of the course is the final assessment, which consists of a written part - problem solutions and their oral presentation, and a test on theory. The final assessment takes into account all the required activities with the relevant weighting. The 4 ECTS credit assessment takes into account the following: participation in direct teaching (2 ECTS credits), self-study and individual homework solution (1 ECTS credit), and passing the final examination (1 ECTS credit).
Final grade scale: A 100% - 85%, B 84% - 70%, C 69% - 55%, D 54% - 40%, E 39% - 20%, FX 19% - 0.

Learning outcomes:
The student will learn the basics of electron and thermal transport in the classical and quantum regime. The student will master Boltzmann and quantum Landauer-Büttiker formalisms to solve standard transport problems and to apply the knowledge independently to similar physics problems. The knowledge gained will help the student to interpret experimental measurements or determine relevant transport physical mechanisms.

Brief outline of the course:

Recommended literature:
1. K. Hirose, N. Kobayashi, Quantum Transport Calculations for Nanosystems, Pan Standford Publishing, 2014.
2. D. K. Ferry, An Introduction to Quantum Transport in Semiconductors, Pan Standford Publishing, 2018.
3. M. Galperin, Quantum Transport, Lecture Notes, 1998.
4. S. Datta, Electronic Transport in Mesoscopic Systems, Cambridge University Press, 1995.
5. M. Di Ventra, Electrical Transport in Nanoscale Systems, Cambridge University Press, 2009.
6. T. Ihn, Electronic Quantum Transport in Mesoscopic Semiconductor Structures, Springer Tracts in Modern Physics, Volume 192, 2004.

7. T. Heinzel, Mesoscopic Electronics in Solid State Nanostructures, Wiley-VCH, 2003.
8. N. W. Ashcroft, N. D. Mermin, Solid State Physics, Harcourt College Publisher, 1976.
7. M. P. Marder, Condensed Matter Physics, Wiley, 2010.
9. J. B. Ketterson, The Physics of Solids, Oxford University Press, 2016.
10. J. Sólyom, Fundamentals of the Physics of Solids, Volume 2 – Electronic Properties, Springer, 2009.

Course language:

Notes:
The course is implemented in a full-time form, if necessary remotely in the MS Teams environment.

Course assessment
Total number of assessed students: 18

A	B	C	D	E	FX
22.22	11.11	38.89	11.11	16.67	0.0

Provides: RNDr. Martin Gmitra, PhD.

Date of last modification: 31.01.2022

Approved: prof. Ing. Martin Orendáč, DrSc.