Course unit tilte: *Fizyki fazy skondensowanej* *Physics of condensed matter*			
Field of study: **Technical Physics**			Course unit code: **P.K.B.14.**
Type of course unit: **Obliga tory**	Level of study: **II level**	Form of study: **Stationary studies**	Year: **I** Semester: **II**
Teaching methods: **Lacture, Tutorials, Laboratory, Seminar, Project**	Number of hours per week: **2, 1, 0, 1, 0**		Number of ECTS credits: **7 ECTS**

Course guide

I COURSE CARD

Course purposes

C1 Expand the knowledge of solid state physics phenomena.

C2 Mastering and complementing skills of using laws of physics in solving problems in condensed matter physics.

C3 Analysis of the physical models in condensed matter physics

C4 Usage of selected research methods of studying the properties of solid state materials and usage of selected instrumentations applied to study solid state materials.

C5 Advanced knowledge of data collection, processing, interpretation, preparing reports and presentations of results.

INITIAL REQUIREMENT FOR THE KNOWLEDGE, ABILITIES AND OTHER COMPETENCES

1. Basic knowledge of physics laws.
2. Knowledge of basic quantum physics.
3. Skills in analysis of physical problems.
4. Knowledge of basic differential and integral calculus
5. Basic knowledge of solid state physics laws
6. Basic skills in preparation of multimedia presentations – skills in Power Point

THE EFFECTS OF EDUCATION

EK 1 – student know theoretical models and laws for condensed matter phenomena

EK 2 – student acquired the advanced knowledge allowing to independently analyze results of measurements,

EK 3 – student know how to apply solid state physics laws to determine properties of materials,

EK 4 – student acquired the advanced knowledge on internal structure of solids,

EK 5 – student acquired the advanced knowledge on dependences between type of atomic bounds and physical properties of solids.

EK 6 – student is able to interpret results of research and collect them in the form of presentation.

EK 7 – student is able to work individually and collectively.

COURSE CONTENT

Teaching method – LECTURE	Number of hours
W 1 – Fundamentals of crystallography: definitions crystal lattice nodes, planes, Miller indexing, elements of crystal symmetry, point groups and space groups, types of Bravais lattices, the description of space groups in International Tables for Crystallography, producing single crystals by Czochralski method and the melting zone method	3
W 2 – Diffraction methods of testing solids: X-ray tube, generation of characteristic radiation X-rays produced by synchrotron, Laue model of X-ray diffraction, Bragg-Wulf equation, reciprocal lattice vs. diffraction pattern – Ewald construction, Lauegrams, Dabaya-Sherrer-Wulf method, Bragg-Brentano configuration, theoretical description of diffraction, electron density, structural factor and dissipation factor vs. cell type Bravais, electron diffraction, neutron diffraction	4
W 3 – **Phase diagram**: the definition of phase-solid solutions - interstitial substitutional, vacances, diffusion and first Fick's law, the intermediate phases - intermetallic compounds, electron phases, Laves phases, interstitial phases, eutectics and eutektoids - plate, bar, grainy and sawmills, forming of eutectic and eutektoids, Gibbs phase rule, phase equilibrium diagram type I, II, III and IV, the peritectic transformation, allotropy, isomorphism, lever rule for determining the percentage of phase ternary phase equilibrium systems	4
W 4 – Electronic structure of solids: the classical theory of free-electron Drude-Lorentz model of electric conductivity in solids, Sommerfeld theory, Wiedemann-Feanza law, Sommerfeld quantum theory, band structure of solids, Kronig-Penney model, Brillouin zone, Brillouin zone vs. Ewald construction, the band structure of insulators, metals and semiconductors, approximation of strongly bound electrons, temperature dependence of resistance for conductors and semiconductors.	4

W 5 – Semiconductor materials and devices: classification, crystal structure, intrinsic semiconductors, electron and hole conductivity, temperature dependence of conductivity for intrinsic semiconductors, doped semiconductors, band structure, influence of doping on electric properties of semiconductors at various temperatures, the mechanisms of recombination of carriers, semiconductor devices - rectifying diode , Zener diode, capacitance diode, light emitting diode, a semiconductor laser, photodiode, photovoltaic cell, junction transistor, field effect transistor, the Hall effect in metals and semiconductors	4
W 6 – **Properties of dielectrics:** dielectric polarization, Lorentz field in dielectrics, dielectric constant and polarizability, equation Classiusa-Mossottiego, variable electric field, electron, ion and dipole polarizability vs. their contributions to the polarizability depending on the frequency, the Lyddane'a-Sachs-Teller relation	2
W 7 – Magnetic properties of solids: the magnetic properties of atoms, orbital and spin magnetic moment of the atom, the classification of magnetic materials, diamagnetism and paramagnetism of solids, the nature of ferromagnetism, ferromagnetism of alloys: ferromagnetic materials, ferrimagnetics and ferrites, basic information about the geometry of domains in ferromagnetics, exchange energy and anisotropy energy in magnetic materials, soft and hard magnetic materials, permanent magnets, magnetic memory elements.	4
W 8 – Superconductivity: the basic properties of the superconducting state, a phenomenological description of superconductivity- Londons equation, elements of the BCS theory, superconducting current and the critical current, the magnetic flux quantization, high temperature superconductors	2
W 9 – **Magnetic resonance:** magnetic resonance, nuclear magnetic resonance (NMR) spectroscopy and its application in NMR tomography, electron resonance and its application to the study of phase transitions in solids.	3

Teaching method – seminar	Number of hours
SEM 1 – Phase analysis by EVA software	1
SEM 2 – Components of X-ray diffractometer	1
SEM 3 – Analysis of X-ray diffractions using the Rietveld method	1
SEM 4 – Processing of metallic glasses	1
SEM 5 – Thin film materials processing techniques	1
SEM 6 – Processing of nanocrystalline materials	1
SEM 7 – Processing of monocrystals.	1
SEM 8 – Application of callorymetry methods to determination of the thermal properties and to construction of the chase diagrams of alloys	1
SEM 9 –Magnetic domain structure observation by Kerr and Bitter microscopy	1
SEM 10 - Scanning electron microscopy	1
SEM 11 – Transmission electron microscopy	1
SEM 12 –Magnetocaloric effect	1

SEM 13 – Measurements of magnetic properties	1
SEM 14 – Synchrotron radiation applied for studying solids	1
Teaching method – TUTORIALS: Problems closely linked to the lecture course	Number of hours
CW 1 – Problems in crystallography	3
CW 2 – Problems in diffraction analysis	3
CW 3 – Problems in chase diagram analysis	2
CW 4 – Problems in electronic structure of solids	2
CW 5 – Problems in semiconductor elements and electric circuits	2
CW 6 – Problems in mgnetic properties of solids.	2
CW 7 –Final test and assessment	1

NARZĘDZIA DYDAKTYCZNE

1. – lecture with use of audiovisual media
2. – tutorials – problems for individual solving and with help of teacher during classes
3. – solid state physics literature
4. –seminar-Mathematica, Microsoft Office, Origin and Corel software , student speech and conducting the discussion - the use of audiovisual media

WAYS OF ASSESSMENT (F – FORMING, P – SUMMARY)

F1. – assessment of individual coursework
P1. – assessment of final test
P2. – assessment of final exam
P3. – assessment of the individual presentations during seminar classes

STUDENT WORKLOAD

Form of activity	Średnia liczba godzin na zrealizowanie aktywności
Contact hours with the teacher Getting acquainted with the indicated literature Study to tutorials Preparation of presentations to seminar Study to final test	30W 15l 15cw → 60h 15 h 15 h 15 h 15 h
Total number of hours	∑ 120 h
TOTAL NUMBER OF ECTS CREDITS FOR THE COURSE	7 ECTS

BASIC AND SUPPLEMENTARY LITERATURE

1. H. Ibach, H. Luth, Fizyka ciała stałego, PWN, Warszawa 1996
2. Ch. Kittel, Wstęp do fizyki ciała stałego, PWN, Warszawa, 1976
3. L. Kalinowski, Fizyka metali, PWN Warszawa 1970
4. C.A. Wert, P.M.Thomson., Fizyka ciała stałego , PWN, Warszawa 1974
5. G.E.R. Schultze, Fizyka metali, , PWN, Warszawa 1982

6.	P. Wilkes, Fizyka ciała stałego dla metaloznawców, PWN, Warszawa 1979
7.	N.M. Ashkroft, Mermin N.D. Fizyka ciała stałego, PWN, Warszawa 1986
8.	A. Oleś, Metody doświadczalne fizyki ciała stałego, WNT Warszawa 1998.
9.	A. Hennel, W. Szuszkiewicz, Zadania z fizyki atomu, cząsteczki i ciała stałego, PWN, Warszawa 1994
10.	F.J. Blatt, Fizyka zjawisk elektronowych w metalach i półprzewodnikach, PWN, Warszawa 1979
11.	Z. Kleszczewki, Podstawy fizyczne elektroniki ciała stałego, WPŚl. Gliwice 2004
12.	A. Sukiennicki, A. Zagórski, Fizyka ciała stałego, WNT Warszawa 1984
13.	J. Stankowski, B. Czyżak, Nadprzewodnictwo, WNT, Warszawa 1999
14.	W. D. Callister Jr., Materials science and engineering, an introduction, John Wiley & Sons, Inc. 1999
15.	R. A. Higgins, Engineering Metallurgy, Applied Physics Metallurgy, Arnold 1993
16.	T. Senkowski, Z. Stasicka, Zarys struktury elektronowej atomow i czasteczek, skrypt UJ, Kraków 1980

LEADING TEACHER (NAME,SURNAME, ADRES E-MAIL)

1. dr hab. Piotr Pawlik, pawlik@wip.pcz.pl

MATRIX OF PERFORMED EFFECTS OF EDUCATION

The education effects	The reference of the particular effect to the effects defined for the entire program (PEK)	Course purposes	Course content	Teachning to aids	Ways of assessment
EK1	K_W13 K_U18 K_K01, K_K02, K_K07	C1, C2, C3, C5	W, CW, SEM	1,2, 3	P1, P2
EK2	K_W13 K_U18 K_K01, K_K02, K_K07	C1, C2, C3, C4, C5	W, CW, SEM	1, 2, 3, 4	F1, P3
EK3	K_W13 K_U18 K_K01, K_K02, K_K07	C1, C2, C3, C5	W, CW, SEM	1, 2, 3, 4	F1,P1, P2, P3
EK4	K_W13 K_U18 K_K01, K_K02, K_K07	C1, C2	W, CW, SEM	1,2, 3	F1, P1, P2
EK5	K_W13 K_U18 K_K01, K_K02, K_K07	C2	W, CW, SEM	1,2, 3	F1,P1, P2
EK6	K_W13 K_U18	C2	W, CW, SEM	1, 2, 3, 4	F1, P1, P2, P3

	K_K01, K_K02, K_K07				
EK7	K_W13 K_U18 K_K01, K_K02, K_K07	C5	W, CW, SEM	4	P3

II.ASSESSMENT FORM - DETAILS

	For grade 2	For grade 3	For grade 4	For grade 5
EK1 Student knows the theoretical models and solid state physics laws	Student does not know the theoretical models and solid state physics laws	Student barely knows the theoretical models and solid state physics laws	Student acquired a systematic knowledge of the theoretical models and solid state physics laws	Student acquired an advanced systematic knowledge of the theoretical models and solid state physics laws
EK2 Student acquired advanced knowledge allowing to individual analysis of measurements	Student hasn’t knowledge allowing to individual analysis of measurements Student nie posiada wiedzy pozwalającej na prowadzenie analizy wyników pomiarowych	Student acquired partial knowledge allowing to individual analysis of measurements	Student acquired knowledge allowing to individual analysis of measurements	Student acquired advanced knowledge allowing to individual analysis of measurements
EK 3 Student has skills in application of solid state physic laws to determining properties of materials	Student hasn’t any skills in application of solid state physic laws to determining properties of materials	Student has limited skills in application of solid state physic laws to determining properties of materials	Student has fair skills in application of solid state physic laws to determining properties of materials	Student has very good skills in application of solid state physic laws to determining properties of materials
EK 4 Student acquired an advanced knowledge of atomic structure of solids	Student didn’t acquired an any knowledge of atomic structure of solids	Student acquired a limited knowledge of atomic structure of solids	Student acquired an moderate knowledge of atomic structure of solids	Student acquired an advanced knowledge of atomic structure of solids
EK 5 Student acquired the advanced knowledge on dependences between types of atomic bounds and selected physical properties of solids	Student didn’t acquired the advanced knowledge on dependences between types of atomic bounds and selected physical properties of solids	Student acquired a limited knowledge on dependences between types of atomic bounds and selected physical properties of solids	Student acquired fair knowledge on dependences between types of atomic bounds and selected physical properties of solids	Student acquired the advanced knowledge on dependences between types of atomic bounds and selected physical properties of solids
EK 6 Student is able to interpret results of measurements	Student is unable to interpret results of measurements	Student in some cases is able to interpret results of measurements	Student in most cases is able to interpret results of measurements	Student in all cases is able to interpret results of measurements

III. *OTHER USEFUL INFORMATION ABOUT THE COURSE (web site WIPMiFS PCZ)*

1. Information where to find presentation of classes, instructions, subjects of seminars etc.
2. Information about the location of the classes,

3. Information about the date of the course (day of the week/time).
4. Information about the consultation (time + place).