PROGRAM OF STUDIES

FACULTY: Microsystem Electronics and Photonics
MAIN FIELD OF STUDY: Electronics and telecommunications
BRANCH OF SCIENCE: technical-engineering
DISCIPLINES: D1 automatics, electronics and electrical engineering
EDUCATION LEVEL: second-level studies
FORM OF STUDIES: full-time studies
PROFILE: general academic
LANGUAGE OF STUDY: English

Content:

Resolution no. 753/32/2016-2020 of the Senate of Wroclaw University of Science and Technology from the 16th of May 2019

In effect since 1.10.2019

,Attachment no. 1 to Programme of Education

ASSUMED LEARNING OUTCOMES

Faculty: Microsystem Electronics and Photonics
Main field of study: Electronics and Telecommunications
Education level: second-level studies
Profile: general academic

Branch of science: engineering and technology
Discipline / disciplines (for several disciplines, please indicate the major discipline)
automatics, electronics and electrical engineering

Explanation of the markings:
P6U – universal first degree characteristics corresponding to education at the first-level studies - 6 PRK level *
P7U – universal first degree characteristics corresponding to education at the second-level studies - 7 PRK level *

P6S – second degree characteristics corresponding to education at the first-level studies - 6 PRK level *
P7S – second degree characteristics corresponding to education at the second-level studies - 7 PRK level *

W - category "knowledge"
U - category "skills"
K - category "social competences"
K (*faculty symbol*) _W1, K (*faculty symbol*) _W2, K (*faculty symbol*) _W3, … - main-field-of study learning outcomes related to the category "knowledge"
K (*faculty symbol*) _U1, K (*faculty symbol*) _U2, K (*faculty symbol*) _U3, … - main-field-of study learning outcomes related to the category "skills"
K (*faculty symbol*) _K1, K (*faculty symbol*) _K2, K (*faculty symbol*) _K3, … - main-field-of study learning outcomes related to the category "social competences"
S (*faculty symbol*) _W.., S (*faculty symbol*) _W.., S (*faculty symbol*) _W.., … - specialization learning outcomes related to the category "knowledge"
S (*faculty symbol*) _U.., S (*faculty symbol*) _U.., S (*faculty symbol*) _U.., … - specialization learning outcomes related to the category "skills"
S (*faculty symbol*) _K.., S (*faculty symbol*) _K.., S (*faculty symbol*) _K.., … - specialization learning outcomes related to the category "social competences"
… _inż. – learning outcomes related to the engineer competences

Main field of study learning outcomes	Description of learning outcomes for the main-field-of study Electronics and Telecommunications Upon completion of the field of study the graduate:	Reference to PRK characteristics		
		Universal first degree characteristics (U)	Second degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 7 levels of PRK	Characteristics for qualifications on 7 levels of PRK
KNOWLEDGE (W)				
K2eit_W01	has extended and deepened knowledge in the area of sciences and disciplines (physics, chemistry, biology, informatics, materials engineering) necessary to understand the essence of phenomena/properties being the result of size reduction, which are used in nanotechnology	P7U_W	P7S_WG	
K2eit_W02	has extended and deepened knowledge in the field of physics, encompassing basis of quantum physics and solid state physics and theoretical and experimental bases of specific phenomena from the area of electronics and photonics, necessary to understand the phenomena (photoelectronic, electro-acoustic, super-conductivity)	P7U_W	P7S_WG	
K2eit_W03	has basic knowledge concerning theory and methods of linear and nonlinear programming used in optimization procedures		P7S_WG	
K2eit_W04	has theoretically grounded knowledge concerning typical techniques and numerical algorithms applied in engineering, such as: numerical differentiation and integration, experiment design, optimization applied to solving equations or equation systems, both linear and nonlinear, numerical interpolation or optimization and systems of differential equations	P7U_W	P7S_WG	
K2eit_W05	knows and understands the elements of mathematical statistics in terms of possibilities of its application in engineering practice and scientific research	P7U_W		
K2eit_W06	has basic knowledge concerning ordinary and partial differential equations, integral equations, theory of stochastic processes (stationary, Markow, renewal, gaussian processes), Hilbert spaces, necessary to understand mathematical problems in sciences of engineering character	P7U_W		

K2eit_W07	has knowledge concerning reliability theory, methods of elements and devices testing, diagnostic methods, basic characteristics in theory of reliability, typical distributions, reliability of systems, estimation of reliability parameters, experiment design, testing and diagnostics as well as failure models		P7S_WG	P7S_WG_INŻ
K2eit_W08	has knowledge concerning basis of operation of force and deflection sensors basing on piezoresistive and piezoelectric effects, methods of calculation of measurement sensitivity and resolution of piezoresistive sensors and designs of MEMS systems		P7S_WG	
K2eit_W09	has ordered, theoretically grounded, general and detailed knowledge in the range of exact and technical sciences in the areas related to the field of study	P7U_W	P7S_WG	P7S_WG_INŻ
K2eit_W10	has knowledge on the basic concepts of production management systems useful for managers of small or middle enterprises; knows modern production systems and production management systems as well as information about finances, market analysis, logistics, people management, which are necessary in strategic management of enterprises		P7S_WK	P7S_WK_INŻ
K2eit_W11	has knowledge necessary to understand economic, legal, social and beyond technical factors of engineering activities and their using in engineering practice		P7S_WK	P7S_WK_INŻ
K2eit_W12	has basic knowledge concerning management, quality management and running a business		P7S_WK	P7S_WK_INŻ
K2eit_W13	has knowledge concerning sensor technologies, including the knowledge necessary to understand the physical and mechanical principles of operation of sensors and actuators; knows relations between their functional parameters and structure; has basic knowledge on sensor and actuators technologies	P7U_W	P7S_WG	P7S_WG_INŻ

Learning outcomes in KNOWLEDGE category for specialization:

- Microsystems (EMS) are presented in **attachment no. I**
- Optoelectronics and Waveguide Technology (EOT) are presented in **attachment no. II**
- Electronics, Photonics, Microsystems (EPM) are presented in **attachment no. III**

SKILLS (U)				
K2eit_U01	is able to assess and use devices/objects with nanometric dimensions (especially semiconductor devices and other ones, made using different technologies)		P7S_UW	P7S_UW_INŻ
K2eit_U02	is able to assess and use the phenomena occurring in solid state materials in quantum electronics applications		P7S_UW	P7S_UW_INŻ
K2eit_U03	using the methods of linear and nonlinear programming, is able to solve problems and tasks, optimizing the goal	P7U_U	P7S_UW	P7S_UW_INŻ
K2eit_U04	is able to use the learned numerical methods for solving typical engineering tasks	P7U_U	P7S_UW	P7S_UW_INŻ
K2eit_U05	has basic practical skills concerning presentation, analysis and interpretation of data and application of statistical methods in the analysis of various physical phenomena	P7U_U	P7S_UK P7S_UW	P7S_UW_INŻ
K2eit_U06	is able to correctly and effectively use the knowledge concerning differential and integral equations, as well as stochastic processes, for qualitative and quantitative analysis of mathematical problems related to the studied engineering discipline	P7U_U	P7S_UW	P7S_UW_INŻ
K2eit_U07	is able to solve problems concerning calculation of reliability characteristics, calculation of parameters using measurement data, planning of testing methods, planning of diagnostic methods	P7U_U	P7S_UW	P7S_UW_INŻ
K2eit_U08	is able to explain the operating principle and basic characteristics and designs of deflection actuators using piezoelectric and electrostatic actuation	P7U_U	P7S_UK	
K2eit_U09	is able, using literature information and basing on the result of own work, integrating, interpreting and critically evaluating, to prepare and give an oral presentation relevant to the field of study	P7U_U	P7S_UW P7S_UK P7S_UU	
K2eit_U10	is able to use the acquired knowledge on modern production systems, processes of production management, market analysis, logistics and people management	P7U_U	P7S_UO P7S_UW	P7S_UW_INŻ
K2eit_U11	is able to formulate and test the hypotheses connected with engineering problems and simple research work		P7S_UW	P7S_UW_INŻ
K2eit_U12	is able to assess the usefulness and possibilities of application of modern achievements in the fields of technique and technology connected with the current field of study		P7S_UW	P7S_UW_INŻ

K2eit_U13	is able to perform critical analysis of the way of functioning and assess novel technical solutions, especially connected with the current field of study, such as devices, objects, systems, processes, services		P7S_UW	P7S_UW_INŻ
K2eit_U14	is able to suggest rationalization proposal/improvements to existing technical solutions		P7S_UW	P7S_UW_INŻ
K2eit_U15	is able to assess and use semiconductor devices and other devices fabricated using various techniques/technologies		P7S_UW	P7S_UW_INŻ
K2eit_U16	is able to define the fields of further education and follow the process of self-learning	P7U_U		
K2eit_U17	knows foreign language at the upper-intermediate level (B2+) used in the studied field of specialization; is able to communicate in work (oral communication and writing), knows more than one foreign language		P7S_UK	
Learning outcomes in SKILLS category for specialization: • Microsystems (EMS) are presented in **attachment no. I** • Optoelectronics and Waveguide Technology (EOT) are presented in **attachment no. II** • Electronics, Photonics, Microsystems (EPM) are presented in **attachment no. III**				
SOCIAL COMPETENCES (K)				
K2eit_K01	shows curiosity about new innovative design solutions and production processes		P7S_KK	
K2eit_K02	perceives the aspects connected with collecting and presentation of measurement data in various areas of engineering practice and the need of using statistical methods for their description	P7U_K	P7S_KK P7S_KR	
K2eit_K03	perceives the necessity of undertaking and putting into practice optimization measures in various areas of life	P7U_K	P7S_KK P7S_KO	
K2eit_K04	takes into account the need of using numerical methods in design process		P7S_KK	
K2eit_K05	can think and act in a creative and entrepreneurial way		P7S_K P7S_KK	
K2eit_K06	properly recognizes, solves, and acting in a team, puts into practice the knowledge concerning analysis of mathematical problems		P7S_KK P7S_KO P7S_KR	

K2eit_K07	is able to properly define priorities for realization of a task defined by himself/herself or other person; can safely perform measurements and work out results of measurements	P7U_K	P7S_KR	
K2eit_K08	is conscious of importance of the issues connected with implementation and functioning in engineering activity of modern production systems, production management systems, logistics and people management	P7U_K	P7S_KK	
K2eit_K09	realizes the need of formulating and sharing in society, also with the use of mass media, the information and opinions concerning achievements in the field of study, and other aspects of electronic engineer's activity, in a clear, commonly understandable way, justifying various points of view	P7U_K	P7S_KO P7S_KR	
K2eit_K10	is conscious of importance and realizes beyond technical aspects and consequences of engineering activity, including its impact on environment and associated with it responsibility for taken decisions	P7U_K	P7S_KO P7S_KR	
K2eit_K11	is able to define priorities for realization of a particular task	P7U_K		
K2eit_K12	properly recognizes and settles dilemmas connected with professional activity		P7S_KR	

Learning outcomes in SOCIAL COMPETENCES category for specialization:

- Microsystems (EMS) are presented in **attachment no. I**
- Optoelectronics and Waveguide Technology (EOT) are presented in **attachment no. II**
- Electronics, Photonics, Microsystems (EPM) are presented in **attachment no. III**

Attachment no. III

Specialization Electronics, Photonics, Microsystems

Specialization learning outcomes	Description of learning outcomes for the specialization Electronics, Photonics, Microsystems Upon completion of the specialization the graduate:	Reference to PRK characteristics		
		Universal first degree characteristics (U)	Second degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 7 levels of PRK	Characteristics for qualifications on 7 levels of PRK
KNOWLEDGE (W)				
S2epm_W01	has extended and deepened knowledge concerning technological processes applied in widely understood thin-film microelectronics, with the use of knowledge on the phenomena occurring in plasma processes conducted at reduced pressure	P7U_W	P7S_WG	
S2epm_W02	has deepened and theoretically grounded knowledge in the field of photonics, including the knowledge necessary to understand the operation of optical telecommunications systems and optical recording and processing of information	P7U_W	P7S_WG	P7S_WG_INŻ
S2epm_W03	has deepened and ordered knowledge concerning applications and design of optical fiber measurement systems used in contemporary technique	P7U_W	P7S_WG	P7S_WG_INŻ
S2epm_W04	has extended deepened and ordered knowledge, from the field of physics and basis of chemistry, necessary to understand the principles of operation of supplying systems in microsystems (principle of operation, technological and design solutions, exploitation parameters)	P7U_W	P7S_WG	P7S_WG_INŻ
S2epm_W05	has ordered and theoretically grounded knowledge related to the structure, operation principles, properties and applications of physical and chemical sensors as well as microsystems made using thick-film and LTCC (Low Temperature Cofired Ceramics) technology; knows trends in the development of LTCC microsystems		P7S_WG	

S2epm_W06	has theoretically grounded knowledge concerning physico-chemical, and technological bases, design, fabrication, operation and applications of analytical microsystems, microreactors, bio-chips and lab-on-chips		P7S_WG	P7S_WG_INŻ
S2epm_W07	has extended and deepened knowledge concerning theoretical and practical aspects of the application of numerical methods for modeling and design in the area of microsystems	P7U_W	P7S_WG	
S2epm_W08	has extended and deepened knowledge in the field of physics, encompassing basis of quantum physics and solid state physics, including the knowledge necessary to understand the physical phenomena having an important impact on the properties of novel materials and operation of advanced photonic devices	P7U_W	P7S_WG	
S2epm_W09	has knowledge concerning the principles of designing electronic devices with the use of optoelectronic and optical fiber subsystems, satisfying presumed input parameters	P7U_W	P7S_WG	
S2epm_W10	has knowledge on the structure and principles of operation of contemporary operating systems, with special emphasis on Linux family and embedded systems; knows the principles of using of low-level system functions as well as programming and configuration of embedded systems intended, among others, for microcontrollers	P7U_W	P7S_WG	
S2epm_W11	has deepened, theoretically grounded knowledge from the field of photonics, including the knowledge necessary to understand the operation of optical telecommunication systems and optical recording and processing of information; has ordered knowledge concerning the devices being components of teleinformatic networks, including the wireless ones	P7U_W	P7S_WG	P7S_WG_INŻ

S2epm_W12	knows the issues concerning the basic optical phenomena in solid state, the structure and technology of device structures, band-gap engineering and the energetic structure on the level of energetic sub-bands with a precise control of built-in potentials, technology of quantum structures and methods of controlling their energetic properties; knows the parameters, structures and operation principles of semiconductor light sources, including the VCSEL or QCL laser structures and the lasers with multidimensional photonic crystals	P7U_W	P7S_WG	P7S_WG_INŻ
S2epm_W13	has ordered, theoretically grounded general and detailed knowledge in the field of exact and technical sciences relevant to the studied specialization; knows basic principles of editing of research projects and diploma thesis	P7U_W	P7S_WG	P7S_WG_INŻ
S2epm_W14	has knowledge in the field of packaging technologies, testing and assessment the quality of bonding of electronic sub-assemblies on printed wire boards; recognizess the physical bacgrounds of soldering process, the soldering technologies applied on industrial scale; has knowledge on industrial safety rules in the bonding and de-bonding process	P7U_W	P7S_WG	P7S_WG_INŻ
S2epm_W15	has theoretically grounded knowledge concerning physico-mechanical, technological, design, fabrication, operation and application bases of microsystems of MEMS and MOEMS type	P7U_W	P7S_WG	
S2epm_W16	has ordered and theoretically grounded knowledge on photovoltaics, including the knowledge necessary to understand physical basis of photovoltaic elements operation as well as designing and quality assessment of photovoltaic systems	P7U_W	P7S_WG	P7S_WG_INŻ
SKILLS (U)				
S2epm_U01	is able to design a technological process of thin-film deposition, including the processes occurring in gas discharge	P7U_U	P7S_UW	P7S_UW_INŻ
S2epm_U02	is able to choose and assess optical fiber and optoelectronic elements used in designing of photonic systems and optical fiber networks; is familiar with the techniques of measurements of waveguides, waveguide couplers and possibilities of their application in waveguide systems		P7S_UW	

S2epm_U03	is able to plan a process of testing of a complex electronic circuit and electronic or photonic system; is able to design electronic circuits and systems intended for different applications, including monolithic and hybrid electronic and photonic circuits		P7S_UW	P7S_UW_INŻ
S2epm_U04	is able to correctly and effectively use the knowledge about differential and integral equations as well as stochastic processes for qualitative and quantitative analysis of mathematical problems relevant to the studied specialization	P7U_U	P7S_UW	P7S_UW_INŻ
S2epm_U05	is able to select and apply, depending on requirements as well as available solutions and exploitation parameters, a proper supplying source for a microsystem		P7S_UW	P7S_UW_INŻ
S2epm_U06	is able to design specific sensors, actuators and microsystems; is able to develop prerequisites concerning design of chosen devices and develop an algorithm of technological process for their fabrication		P7S_UW	P7S_UW_INŻ
S2epm_U07	is able to describe, assess and compare the operation of analytic gaseous and fluidic microsystems; knows the principles of design, fabrication, operation and application of microsystems in chemistry and microchemistry		P7S_UW	P7S_UW_INŻ
S2epm_U08	is able to use the acquired knowledge for carrying out the studies of the components of analytical microsystems (valves, metering units, mixers and detectors); is familiar with the operation principles of advanced analytical microsystems (e.g. integrated gas chromatograph)		P7S_UW	P7S_UW_INŻ
S2epm_U09	is able to plan and safely carry out measurements and work out the measurement results		P7S_UW	P7S_UW_INŻ
S2epm_U10	is able - while formulating and solving tasks associated with modeling and design of microsystems - to integrate knowledge coming from different sources		P7S_UW	
S2epm_U11	is able to develop detailed documentation of the results of experiment, a design or research project; is able to prepare a report containing discussion of the results		P7S_UK	

S2epm_U12	is able to develop a system solution and define the physical phenomenon from the field of optoelectronics and waveguide technology, satisfying the given project task; is able to plan a design process, is able to develop electronic schemes of a device, design printed wire boards and casing, and asses the cost of fabrication of the device		P7S_UW P7S_UW	P7S_UW_INŻ
S2epm_U13	has a skill of using low-level system functions as well as program and configure embedded systems intended for microcontrollers		P7S_UW	
S2epm_U14	is able to work individually and in a team; is able to assess time consumption for task execution; is able to manage a small team in a way ensuring completion of the task in due time; is able to prepare and give a presentation on realization of a task or research project and conduct a discussion concerning the presentation; is able to use English at the level sufficient for communication, also in professional issues, reads with understanding professional literature and is able to prepare and give a short oral presentation on realization of a task or research project	P7U_U	P7S_UW P7S_UK P7S_UO P7S_UU	
S2epm_U15	is familiar with the techniques and measuring stands for characterization of epitaxial device structures and can use them in practice; knows and is able to apply optical spectroscopic methods, such as photoluminescence, photo reflection or electronic reflection, for the characterization quantum properties of semiconductor structures		P7S_UW	P7S_UW_INŻ
S2epm_U16	is able to implement the regulations of WEEE and RoHS directives; is able to recognize and eliminate the bonding faults described in IPC standards		P7S_UW	P7S_UW_INŻ
S2epm_U17	has a sikll of manual soldering using resistance and gas soldering tools; is able to carry out reflow soldering process and manual debonding, using a professional service station; is able to match the parameters of soldering process to the applied materials		P7S_UW	P7S_UW_INŻ

S2epm_U18	is able, using literature information and basing on the results of own work, while integrating, interpreting and making critical evaluation, to prepare diploma thesis and give an oral presentation relevant to the field of study	P7U_U	P7S_UW P7S_UK P7S_UU	
S2epm_U19	is able to identify and formulate specification of complex engineering tasks (relevant to the field of study) taking into account their beyond technical aspects		P7S_UW	
S2epm_U20	is able to solve problems concerning: calculation of reliability characteristics, calculation of parameters with the use of measurement data, planning of testing methods, planning of diagnostics methods		P7S_UW	P7S_UW_INŻ
SOCIAL COMPETENCES (K)				
S2epm_K01	is able to work individually and in a team	P7U_K		
S2epm_K02	is open to novel innovative design solutions and production processes applied in electronics and photonics		P7S_KK	
S2epm_K03	is able to think and act in innovative and entrepreneurial way	P7U_K	P7S_KK	
S2epm_K04	perceives the necessity of functionality assessment of optoelectronic systems in different areas of life and is able to take effective measures to put such solutions in practice	P7U_K	P7S_KK P7S_KO	
S2epm_K05	properly identifies, solves and puts into practice, co-operating in a team, the knowledge connected with the analysis of engineering problems		P7S_KK P7S_KO P7S_KR	
S2epm_K06	takes into account the necessity to use numerical methods in the design process of photonic and microelectronic structures		P7S_KK	
S2epm_K07	is able to properly define the priorities for realization of a task defined by himself/herself or other person; is able to perform measurements safely and work out results of measurements	P7U_K		
S2epm_K08	is conscious of the importance and understands the necessity of putting into practice renewable energy sources	P7U_K	P7S_KK	
S2epm_K09	is able to plan and develop a project implementation plan, is able to interact and work in a group, taking on different roles	P7U_K	P7S_KR	

Attachment no. 2 to Program of Studies

DESCRIPTION OF THE PROGRAM OF STUDIES

1. General description

1.1 Number of semesters: ***3***	*1.2 Total number of ECTS points necessary to complete studies at a given level:* ***90***
1.3 Total number of hours: *for studies in English – 1110*	*1.4 Prerequisites (particularly for second-level studies):* The procedure, mode and recruitment requirements are annually determined by the Wrocław University of Science and Technology Senate. Information on recruitment for studies can be found on the website of the Wrocław University of Science and Technology Recruitment Department. As an additional requirement for admission for the second-level studies, the candidate should complete the studies from the list of related fields. The list is published on the website of the Wrocław University of Science and Technology Recruitment Department.
1.5 Upon completion of studies graduate obtains *professional degree of:* ***magister inżynier***	*1.6 Graduate profile, employability:* *The graduate can design and use electronic integrated circuits - using analogue and digital technology, lasers, optical fibers and photovoltaic cells - using modern technologies. He can design and operate telecommunications and teleinformation networks, manufacture and use micro and nanosystems, ie sensors and microsensors and microrobots used in medicine, pharmaceutical industry, automotive, aviation, environmental protection and objects protection. The graduate has in-depth knowledge enabling quick adaptation to the dynamically changing IT reality and in the scope of new materials and new technologies. Offered in the field of "electronics and telecommunications", specialties (EOT, EMS, EPM) give the possibility of universal preparation of graduates and cover the issues of electronics, photonics, computer science, optoelectronics and telecommunications, which is their great asset on the modern labor market.*

	Specific practical knowledge acquired thanks to the access to modern computer and network hardware and software, knowledge of foreign languages allow graduates to take up studies at the third level of education at national universities and universities in the European Union. The graduate has both the ability to take independent engineering projects, participate in team work, and manage teams of people.
1.7 Possibility of continuing studies: ***Graduate is prepared for the 3-rd level study***	*1.8 Indicate connection with University's mission and its development strategy:* In accordance with the mission of the University and the "Strategy for Development of Wrocław University of Science and Technology 2016-2020", the Wroclaw University of Science and Technology is a technical university, which as an autonomous technical university, university research institution recognizes the creative, critical and tolerant personality of students and PhD students as well as setting directions for the development of science and technology. The university, in the service of the society, realizes its mission through: inventions and innovations, the highest standards in scientific research, transfer of knowledge, high quality of education and freedom of criticism with respect for the truth. The Faculty of Microsystem Electronics and Photonics is one of its units, that is important in the implementation and combining of high theoretical, research and expert competences with didactic and educational competences. The concept of education / educational model adopted at the Faculty fulfills the standards written in the university documents and the Development Strategy of the Microsystem Electronics and Photonics (Resolution No. 128/13/2012-2016) expressed by the Development Plan of the Microsystem Electronics and Photonics and Strategic Objectives of the Faculty together with merits of their implementation. The concept of education at the Faculty takes into account the perspective of the development of higher education set by the Ministry of Science and Higher Education for 2015-2030.

2. Detailed description

2.1 Total numer of learning outcomes in the program of study: W (knowledge) = 29, U (skills) = 37, K (competences) = 21 W + U + K = 87

2.2 For the main field of study assigned to more than one discipline - the number of learning outcomes assigned to the discipline: not applicable

2.3 For the field of study assigned to more than one discipline - percentage share of the number of ECTS points for each discipline: not applicable

2.4 For the general academic profile field of study – the number of ECTS points assigned to the classes related to the University's academic activity in the discipline or disciplines to which the faculty is assigned (must be greater than 50% of the total number of ECTS points from 1.1): 78 ECTS

2.5 Concise analysis of compliance of the assumed learning outcomes with the needs of the labor market

When educating in a general academic profile, the Faculty offers its education to graduates of first and second level studies and other groups interested in the development and improvement of qualifications acquired outside formal education. Ultimately, studies on this profile should prepare a professional staff for the economy and science, including project leaders, research groups and technical teams. Education in the field of Electronics and Telecommunications (EiT) is concurrent with the strategic framework for smart specializations of Lower Silesia in the area of electronics and related areas as well as National Smart Specialization (KIS 8, 9, 11 and 13).

The resources of knowledge, skills and social competences of students / graduates of the EiT course are the result of attributing learning outcomes to a specific degree of study related to the courses provided. Learning outcomes, determined for the directional courses and in the scope of a given specialty, are referred to the learning outcomes for the area of engineering and technical sciences. They should provide students / graduates with deep, structured and theoretically founded knowledge, which is advanced general knowledge of the discipline of automatics, electronics and electrical engineering, containing the main developmental trends of the discipline and selected issues in the field of detailed knowledge concerning, among others. selected facts, objects and phenomena and related methods and theories, explaining the complex relationships between them. The adopted solution regarding the increase of competences in the transition to a higher level of qualifications, while ensuring the "openness" of the second degree studies, gives the opportunity to acquire more advanced knowledge and skills (with specific social competences) in a narrower thematic scope. Potential future employers in the region are informed about the level of knowledge, skills and social competences attained by students / graduates through the industry representatives included in the Faculty Convent and affecting the range of determined learning outcomes.

The acquired basic knowledge as well as detailed knowledge in the field should be wide enough for the student / graduate of the faculty to be able to adapt their competences to the changing conditions and challenges that will be faced by him during his decades-long professional career. Employers implementing a modern work organization and innovative technologies in their companies have such expectations. The effects attributed to the courses, achieved during the education process, will ensure, in accordance with the expectations of future employers, that the graduate possesses knowledge about development trends and new, recently implemented achievements not only in the field of electronics and telecommunications, optoelectronics, photonics, computer science, but also in such areas as, among others medicine or environmental protection.

The assumed effect, achieved in the education process, regarding knowledge, is the graduate's advanced knowledge about technology transfer and knowledge related to management (including quality management) and running a business. The effect of education should also be general knowledge, taken into account in engineering practice, necessary to understand social, economic, legal and other, non-technical conditions of engineering activities. Such effects are achieved by implementing university-wide courses. Such knowledge will enable the graduate to understand the realities relating to the organization of production processes and the conditions in which they are conducted. It will also allow him to take into account such conditions in his individual work and teamwork, which as a result of achieving effects he is able to take responsibly. This kind of knowledge resource from the university graduate is expected by the modern labor market. The learning courses included in the course

cards, implemented in the field of study, ensure that the graduate achieves the ability to integrate the knowledge of various fields and disciplines with the application of a system approach in the formation and solving of engineering tasks. The labor market expects that the results achieved in the education process will ensure that the graduate is prepared to work in an industrial environment with the knowledge of work safety principles, in particular with work at a specific position / device. In this respect, the effects achieved in the implementation of laboratory-type courses are important here. A student / graduate should see the need to improve and improve the production process, or existing technical solutions at the workplace. After achieving the learning outcomes, he / she should be able to, taking into account non-technical aspects, according to the given specification, design and execute (using appropriate methods, techniques and tools) a complex device, system or process.
Bearing in mind that the task of assumed and achieved learning outcomes is to meet, to the greatest extent, the expectations of entrepreneurs employing our graduates, an important element of the assessment of the educational process are the hospitations and departmental surveys addressed to students and graduates during each semester. Verification of compliance of the assumed learning outcomes with market expectations and needs is also taking place during the numerous contacts of our graduates with the Faculty's employees.

2.6. The total number of ECTS points that a student must obtain in classes requiring direct participation of academic teachers or other persons conducting classes and students (enter the sum of ECTS points for courses / groups of courses marked with the BK1 code) 59,7 ECTS

2.7. Total number of ECTS points, which student has to obtain from basic sciences classes

Number of ECTS points for obligatory subjects	6
Number of ECTS points for optional subjects	0
Total number of ECTS points	6

2.8. Total number of ECTS points, which student has to obtain from practical classes, including laboratory classes (enter total number of ECTS points for courses/group of courses denoted with code P)

Number of ECTS points for obligatory subjects	12
Number of ECTS points for optional subjects	42
Total number of ECTS points	54

2.9. Minimum number of ECTS points, which student has to obtain doing education blocks offered as part of university-wide classes or other main field of study (enter number of ECTS points for courses/groups of courses denoted with code O) 9 ECTS points

2.10. Total number of ECTS points, which student may obtain doing optional blocks (min. 30% of total number of ECTS points)
62 ECTS points

3. Description of the process leading to learning outcomes acquisition:

Students achieve the assumed learning outcomes primarily during classes organized by the university as part of the educational process. Learning outcomes assigned to the category of "knowledge", including the content of education associated with them, are provided during lectures and seminar classes. Effects including skills, social and engineering competences are achieved in practical classes, with direct contact with academic teachers, conducted in the form of exercises, laboratories or project classes.

The diploma thesis implemented by students, including complex engineering problems as well as measurement and research issues, enables the student to consolidate the obtained learning outcomes. In the education process, students carry out classes in the Faculty's modern technological and research laboratories. These classes are related to the research projects conducted at the Faculty concerning new and current research areas, thanks to which students gain research experience and have the opportunity to participate in scientific research.

Students have the opportunity to take advantage of additional, non-obligatory forms of education that facilitate achieving learning outcomes through participation in consultations, laboratory consultations, compensatory courses and additional classes co-organized by the Faculty with industry external companies (e.g. as part of the LabVIEW Academy or IQRF Smart School program).

The achievement of the assumed learning outcomes by students is verified on a regular basis by means of a systematic assessment carried out in the form of: tests, oral answers, reports, laboratory protocols, projects or multimedia presentations. In lectures, achieving the expected learning outcomes, including a wider range of learning content, is verified by tests, partial or final exams.

4. List of education blocks:

4.1. List of obligatory blocks:

4.1.1 List of general education blocks

4.1.1.1 *Liberal-managerial subjects* block *(5 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	FLD129580W	Philosophy of Science and Technology	1					K2eit_K09 K2eit_K10 K2eit_K12	15	60	2	1,2	T	Z	O		KO	Ob
2.	ZMZ000134W	Contemporary Management	2					K2eit_W10 K2eit_W11 K2eit_W12 K2eit_U10 K2eit_K05 K2eit_K08 K2eit_K11	30	90	3	1,8	T	Z	O		KO	Ob
		Total	3	0	0	0	0		45	150	5	3						

4.1.1.2 *Foreign languages* block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

4.1.1.3 *Sporting classes* block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

4.1.1.4 *Information technologies* block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

Altogether for general education blocks

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
3	0	0	0	0	45	150	5	3

4.1.2 List of basic sciences blocks

4.1.2.1 *Mathematics* block

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	MAT001449W	Mathematics	2					K2eit_W06	30	60	2	1,2	T	E	O		PD	Ob
2.	MAT001449C	Mathematics		2				K2eit_U06 K2eit_K02	30	60	2	1,4	T	Z	O	P	PD	Ob
		Total	2	2	0	0	0		60	120	4	2,6						

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

4.1.2.2 *Physics* block

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/ group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ETD008084W	Solid State Electronics	2					K2eit_W02 K2eit_U02	30	60	2	1,2	T	Z			PD	Ob.
		Total	2	0	0	0	0		30	60	2	1,2						

4.1.2.3 *Chemistry* block

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

4.1.2.4 *Informatics* block

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

Altogether for basic sciences blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
4	2	0	0	0	90	180	6	3,8

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

4.1.3 List of main-field-of-study blocks

4.1.3.1 *Obligatory main-field-of-study* blocks

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ETD008081W	Statistics for EPM	1					K2eit_W05	15	30	1	0,6	T	Z			K	Ob
2.	ETD008081C	Statistics for EPM		1				K2eit_U05 K2eit_K02	15	60	2	1,4	T	Z		P	K	Ob
3.	ETD008082W	Numerical Methods	1					K2eit_W04 K2eit_K07	15	30	1	0,6	T	Z			K	Ob
4.	ETD008082L	Numerical Methods			1			K2eit_U04 K2eit_K04 K2eit_K07	15	60	2	1,4	T	Z		P	K	Ob
5.	ETD008083W	Optimization Methods	1					K2eit_W03	15	30	1	0,6	T	Z			K	Ob
6.	ETD008083C	Optimization Methods		1				K2eit_U03 K2eit_U11 K2eit_K03	15	60	2	1,4	T	Z		P	K	Ob
7.	ETD008085W	Nanotechnology	1					K2eit_W01 K2eit_W09	15	30	1	0,6	T	Z			K	Ob
8.	ETD008085S	Nanotechnology					2	K2eit_U01 K2eit_U15 K2eit_K01	30	60	2	1,4	T	Z		P	K	Ob
9.	ETD009588W	Sensors and Actuators	1					K2eit_W08 K2eit_W13 K2eit_U08	15	60	2	1,2	T	Z			K	Ob
10.	ETD009079W	Diagnostics and Reliability	1					K2eit_W07	15	30	1	0,6	T	Z			K	Ob
11.	ETD009079P	Diagnostics and Reliability				1		K2eit_U07 K2eit_K06	15	60	2	1,4	T	Z		P	K	Ob
		Total	6	2	1	1	2		180	510	17	11,2						

Altogether (for main-field-of-study blocks):

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
6	2	1	1	2	180	510	17	11,2

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

4.2 List of optional blocks

4.2.1 List of general education blocks

4.2.1.1 Liberal-managerial subjects blocks *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

4.2.1.2 *Foreign languages* block *(3 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/ group of courses	Way[3] of creditin g	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	JZL100709BK	Foreign Language 2B+		1				K2eit_U17	15	30	1	0,7	T	Z	O	P	KO	W
2.	JZL100710BK	Foreign Language A1/A2		3				K2eit_U17	45	60	2	1,4	T	Z	O	P	KO	W
		Total	0	4	0	0	0		60	90	3	2,1						

4.2.1.3 Sporting classes block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

4.2.1.4 *Information technologies* block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

Altogether for general education blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
0	4	0	0	0	60	90	3	2,1

4.2.2 List of basic sciences blocks

4.2.2.1 *Mathematics* block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

4.2.2.2 *Physics* block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

4.2.2.3 *Chemistry* block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

Altogether for basic sciences blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				

4.2.3 List of main-field-of-study blocks

4.2.3.1 Main-field-of-study optional block *(0 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
		Total																

Altogether for main-field-of-study blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				

4.2.4 List of specialization blocks

4.2.4.1 *Specialization subjects (Electronics, Photonics, Microsystem)* block *(59 ECTS points):*

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ETD009589W	MOEMS	1					S2epm_W06 S2epm_W15	15	30	1	0,6	T	Z			S	W

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

2.	ETD009589L	MOEMS			1			S2epm_U11 S2epm_K01	15	60	2	1,4	T	Z		P	S	W
3.	ETD008564W	Optical Fibers	2					S2epm_W02 S2epm_W03	30	60	2	1,2	T	E			S	W
4.	ETD008564L	Optical Fibers			2			S2epm_U02 S2epm_K01	30	60	2	1,4	T	Z		P	S	W
5.	ETD008568W	Vacuum and Plasma Techniques	2					S2epm_W01	30	30	1	0,6	T	Z			S	W
6.	ETD008566W	Autonomous Power Supplying Systems	2					K2eit_W11 S2epm_W04 S2epm_U05 S2epm_K08	30	60	2	1,2	T	Z			S	W
7.	ETD009584W	Advanced Optoelectronics	1					S2epm_W12 S2epm_W08	15	30	1	0,6	T	E	O		S	W
8.	ETD009584L	Advanced Optoelectronics			1			S2epm_U03 S2epm_U15 S2epm_K04	15	30	1	0,7	T	Z			S	W
9.	ETD009584P	Advanced Optoelectronics				2		S2epm_U03 S2epm_U15 S2epm_K04	30	60	2	1,4	T	Z		P	S	W
10.	ETD009571W	Optical-Fiber Networks	1					S2epm_W02 S2epm_W11	15	30	1	0,6	T	Z			S	W
11.	ETD009571P	Optical-Fiber Networks				1		S2epm_U02 S2epm_K09	15	30	1	0,7	T	Z		P	S	W
12.	ETD009572W	Operating Systems	1					S2epm_W10	15	30	1	0,6	T	Z			S	W
13.	ETD009572L	Operating Systems			1			S2epm_U13 S2epm_K01	15	60	2	1,4	T	Z		P	S	W
14.	ETD009583W	Design and Construction of Optoelectronics Circuits	1					S2epm_W09	15	30	1	0,6	T	Z			S	W
15.	ETD009583P	Design and Construction of Optoelectronics Circuits				1		S2epm_U02 S2epm_U12 S2epm_K09	15	60	2	1,4	T	Z		P	S	W
16.	ETD009574W	Photovoltaics	2					S2epm_W16	30	60	2	1,2	T	Z			S	W
17.	ETD009574L	Photovoltaics			2			S2epm_U11 S2epm_K01	30	60	2	1,4	T	Z		P	S	W
18.	ETD009575W	Microsystem Modeling	1					S2epm_W07	15	30	1	0,6	T	Z			S	W
19.	ETD009575L	Microsystem Modeling			2			S2epm_U04 S2epm_U10 S2epm_K06 S2epm_K09	30	60	2	1,4	T	Z		P	S	W
20.	ETD009576W	Analytical Microsystems	1					S2epm_W06	15	30	1	0,6	T	Z			S	W
21.	ETD009576L	Analytical Microsystems			1			S2epm_U07 S2epm_U08 S2epm_U09 S2epm_K01	15	60	2	1,4	T	Z			S	W

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students

[2]Traditional – enter T, remote – enter Z

[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)

[4]University-wide course /group of courses – enter O

[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses

[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization

[7] Optional – enter W, obligatory – enter Ob

22.	ETD009582W	Ceramic Microsystems	2					S2epm_W05 S2epm_U06	30	60	2	1,2	T	E			S	W
23.	ETD009582P	Ceramic Microsystems				1		S2epm_U06 S2epm_K02	15	30	1	0,7	T	Z		P	S	W
24.	ETD009585W	Packaging of EPM	1					S2epm_W14	15	30	1	0,6	T	Z			S	W
25.	ETD009585L	Packaging of EPM			2			S2epm_U16 S2epm_U17 S2epm_K07	30	30	1	0,7	T	Z		P	S	W
26.	ETD009586S	Diploma Seminar					2	K2eit_W01-K2eit_W12, S2epm_W01-S2epm_W14 K2eit_U01-K2eit_U16, S2epm_U01-S2epm_U19 S2epm_K01 S2epm_K03 S2epm_K05	30	60	2	1,4	T	Z		P	S	W
27.	ETD009581D	MSc Thesis Work				12		K2eit_W01-K2eit_W12, S2epm_W01-S2epm_W14 K2eit_U01-K2eit_U16, S2epm_U01-S2epm_U20 K2eit_K01-K2eit_K12, S2epm_K01-S2epm_K09	180	600	20	14	T	Z		P	S	W
		Total	18	0	12	17	2		735	1770	59	39,6						

Altogether for specialization blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
18	0	12	17	2	735	1770	59	39,6

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

4.3 Training block

Name of training			
Number of ECTS points	**Number of ECTS points for BK classes[1]**	**Training crediting mode**	**Code**

Training duration	Training objective

4.4 „Diploma dissertation" block

Type of diploma dissertation	magisterska	
Number of diploma dissertation semesters	**Number of ECTS points**	**Code**
1	**20**	**EPM: ETD009581D**

Character of diploma dissertation

Faculty students may, in the collection of topics of diploma dissertations, choose a diploma dissertation of different characters:
- analytical, (analysis, e.g. numerical, properties)
- technological (Technology of epitaxial growth)
- project (Project of a sensor)
- design (Laboratory stand for annealing by RTS method)
- application (Assessment of applicability)
- usage (Application of a heterostructure in construction)
- research (Testing, characterization)
- survey (Current state of knowledge concerning the growth mechanisms)

Number of BK[1] ECTS points	**14**

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

5. Ways of verifying assumed learning outcomes

Type of classes	Ways of verifying assumed learning outcomes
lecture	exam, test, oral answers, written assessment
class	test, oral answers, discussion, report, activity
laboratory	test, oral answers, discussion, report, activity, mean marks from laboratories
project	test, oral answer, discussion, report, activity, project, project defence, attendance, presentation
seminar	oral answers, discussion, activity, presentation, issues
diploma dissertation	prepared diploma dissertation

6. Range of diploma examination

The scope of the diploma exam covers the content of education provided as part of the studies. The list of current diploma issues in a given academic year is updated annually (in consultation with academic teachers supervising individual courses and approved by the Program Committee) and published on the Faculty's website. The lists cover issues concerning the content of education of directional courses and specialization courses.

7. Requirements concerning deadlines for crediting courses/groups of courses for all courses in particular blocks

No.	*Course / group of courses code*	*Name of course / group of courses*	*Crediting by deadline of... (number of semester)*

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

8. Plan of studies (attachment no. 3c)

Approved by faculty student government legislative body:

....
Date name and surname, signature of student representative

....
Date Dean's signature

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

Attachment no. 3c to Program of Studies

PLAN OF STUDIES

FACULTY: Microsystem Electronics and Photonics

MAIN FIELD OF STUDY: Electronics and telecommunications

EDUCATION LEVEL: second-level studies

FORM OF STUDIES: full-time studies

PROFILE: general academic

SPECIALIZATION: Electronics, Photonics, Microsystems

LANGUAGE OF STUDY: ENGLISH

Resolution no. 753/32/2016-2020 of the Senate of Wrocław University of Science and Technology from the 16th of May 2019

In effect since 1.10.2019

Plan of studies structure in point and hourly layout

2nd level studies
full-time
main field of study: Electronics and Telecommunications,
specialization: Electronics, Photonics, Microsystems

sem. 1							sem. 2							sem. 3						
		lec	cl	lab	pr	sem			lec	cl	lab	pr	sem			lec	cl	lab	pr	sem
														obligatory courses						
														optional courses						
														specialization courses						
Autonomous Power Supplying Systems		2																		
ETD008566		2																		
Vacuum and Plasma Techniques	E	1					Ceramic Microsystems	E	2			1								
ETD008568		2					ETD009582		2			1								
Optical Fibers	E	2		2			Analytical Microsystems		1		2									
ETD008564		2		2			ETD009576		1		1									
MOEMS		1		2			Microsystem Modeling		1		2									
ETD009589		1		1			ETD009575		1		2									
Nanotechnology		1				2	Photovoltaics		2		2									
ETD008085		1				2	ETD009574		2		2									
Solid State Electronics		2					Design and Construction of Optoelectronics Circuits		1			2		Packaging of EPM		1		1		
ETD008083		2					ETD009583		1			1		ETD009585		1		2		
Optimization Methods		1	2				Operating Systems		1		2			Diploma Seminar					2	
ETD008083		1	1				ETD009572		1		1			ETD009586					2	
Numerical Methods		1		2			Optical-Fiber Networks		1			1		MSc Thesis Work				20		
ETD008082		1		1			ETD009571		1			1		ETD009581D				2		
Statistics for EPM		1	2				Advanced Optoelectronics	E	1		1	2		Sensors and Actuators		2				
ETD008081		1	1				ETD009584		1		1	2		ETD009588		1				
Mathematics	E	2	2				Contemporary Management		3					Diagnostics and Reliability		1		2		
MAT001449		2	2				ZMZ000134		2					ETD009079		1		1		
Foreign Language B2+				1			Foreign Language A1/A2				2			Philosophy of Science and Technology				2		
JZL100709BK				1			JZL100710BK				3			FLD129580		1				
		lec	cl	lab	pr	sem			lec	cl	lab	pr	sem			lec	cl	lab	pr	sem
sem. 1							sem. 2							sem. 3						
29	ECTS	14	7	6	0	2	30	ECTS	13	2	9	6	0	31	ECTS	6	0	1	22	2
26	hours	15	5	4	0	2	27	hours	12	3	7	5	0	11	hours	4	0	2	3	2

total	lec	cl	lab	pr	sem
	31	8	13	8	4
	64				

ECTS 90

Set of obligatory and optional courses and groups of courses in semestral arrangement

Semester 1

Obligatory courses / groups of courses Number of ECTS points 18

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/ group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	MAT001449W	Mathematics	2					K2eit_W06	30	60	2	1,2	T	E	O		PD	Ob
2.	MAT001449C	Mathematics		2				K2eit_U06 K2eit_K02	30	60	2	1,4	T	Z	O	P	PD	Ob
3.	ETD008081W	Statistics for EPM	1					K2eit_W05	15	30	1	0,6	T	Z			K	Ob
4.	ETD008081C	Statistics for EPM		1				K2eit_U05 K2eit_K02	15	60	2	1,4	T	Z		P	K	Ob
5.	ETD008082C	Numerical Methods	1					K2eit_W04 K2eit_K07	15	30	1	0,6	T	Z			K	Ob
6.	ETD008082L	Numerical Methods			1			K2eit_U04 K2eit_K04 K2eit_K07	15	60	2	1,4	T	Z		P	K	Ob
7.	ETD008083W	Optimization Methods	1					K2eit_W03	15	30	1	0,6	T	Z			K	Ob
8.	ETD008083C	Optimization Methods		1				K2eit_U03 K2eit_U11 K2eit_K03	15	60	2	1,4	T	Z		P	K	Ob
9.	ETD008084W	Solid State Electronics	2					K2eit_W02 K2eit_U02	30	60	2	1,2	T	Z			PD	Ob
10.	ETD008085W	Nanotechnology	1					K2eit_W01 K2eit_W09	15	30	1	0,6	T	Z			K	Ob
11.	ETD008085S	Nanotechnology					2	K2eit_U01 K2eit_U15 K2eit_K01	30	60	2	1,4	T	Z		P	K	Ob
		Total	8	4	1	0	2		225	540	18	11,8						

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

Optional courses / groups of courses (165 hours in semester, 11 points ECTS)

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/group up of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ETD009589W	MOEMS	1					S2epm_W06 S2epm_W15	15	30	1	0,6	T	Z			S	W
2.	ETD009589L	MOEMS			1			S2epm_U11 S2epm_K01	15	60	2	1,4	T	Z		P	S	W
3.	ETD008564W	Optical Fibers	2					S2epm_W02 S2epm_W03	30	60	2	1,2	T	E			S	W
4.	ETD008564L	Optical Fibers			2			S2epm_U02 S2epm_K01	30	60	2	1,4	T	Z		P	S	W
5.	ETD008568W	Vacuum and Plasma Techniques	2					S2epm_W01	30	30	1	0,6	T	Z			S	W
6.	ETD008566W	Autonomous Power Supplying Systems	2					K2eit_W11 S2epm_W04 S2epm_U05 S2epm_K08	30	60	2	1,2	T	Z			S	W
7.	JZL100709BK	Foreign Language B2+		1				K2eit_U17	15	30	1	0,7	T	Z	O	P	KO	W
		Total	7	1	3	0	0		165	330	11	7,1						

Altogether in semester:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
15	5	4	0	2	390	870	29	18,9

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

Semester 2

Obligatory courses / groups of courses Number of ECTS points 3

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/ group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ZMZ000134W	Contemporary Management	2					K2eit_W10 K2eit_W11 K2eit_W12 K2eit_U10 K2eit_K05 K2eit_K08 K2eit_K11	30	90	3	1,8	T	Z	O		KO	Ob
		Total	2	0	0	0	0		30	90	3	1,8						

Optional courses / groups of courses (375 hours in semester, 27 points ECTS)

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/ group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ETD009584W	Advanced Optoelectronics	1					S2epm_W12 S2epm_W08	15	30	1	0,6	T	E	O		S	W
2.	ETD009584L	Advanced Optoelectronics			1			S2epm_U03 S2epm_U15 S2epm_K04	15	30	1	0,7	T				S	W
3.	ETD009584P	Advanced Optoelectronics				2		S2epm_U03 S2epm_U15 S2epm_K04	30	60	2	1,4	T			P	S	W
4.	ETD009571W	Optical-Fiber Networks	1					S2epm_W02 S2epm_W11	15	30	1	0,6	T				S	W
5.	ETD009571P	Optical-Fiber Networks				1		S2epm_U02 S2epm_K09	15	30	1	0,7	T			P	S	W
6.	ETD009572W	Operating Systems	1					S2epm_W10	15	30	1	0,6	T				S	W
7.	ETD009572L	Operating Systems			1			S2epm_U13 S2epm_K01	15	60	2	1,4	T			P	S	W

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

8.	ETD009583W	Design and Construction of Optoelectronics Circuits	1					S2epm_W09	15	30	1	0,6	T				S	W
9.	ETD009583P	Design and Construction of Optoelectronics Circuits				1		S2epm_U02 S2epm_U12 S2epm_K09	15	60	2	1,4	T			P	S	W
10.	ETD009574W	Photovoltaics	2					S2epm_W16	30	60	2	1,2	T				S	W
11.	ETD009574L	Photovoltaics			2			S2epm_U11 S2epm_K01	30	60	2	1,4	T			P	S	W
12.	ETD009575W	Microsystem Modeling	1					S2epm_W07	15	30	1	0,6	T				S	W
13.	ETD009575L	Microsystem Modeling			2			S2epm_U04 S2epm_U10 S2epm_K06 S2epm_K09	30	60	2	1,4	T			P	S	W
14.	ETD009576W	Analytical Microsystems	1					S2epm_W06	15	30	1	0,6	T				S	W
15.	ETD009576L	Analytical Microsystems			1			S2epm_U07 S2epm_U08 S2epm_U09 S2epm_K01	15	60	2	1,4	T				S	W
16.	ETD009582W	Ceramic Microsystems	2					S2epm_W05 S2epm_U06	30	60	2	1,2	T	E			S	W
17.	ETD009582P	Ceramic Microsystems				1		S2epm_U06 S2epm_K02	15	30	1	0,7	T			P	S	W
18.	JZL100710BK	Foreign Language A1/A2		3				K2eit_U17	45	60	2	1,4	T	Z	O	P	KO	W
		Total	10	3	7	5	0		375	810	27	17,9						

Altogether in semester:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
12	3	7	5	0	405	900	30	19,7

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students

[2]Traditional – enter T, remote – enter Z

[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)

[4]University-wide course /group of courses – enter O

[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses

[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization

[7] Optional – enter W, obligatory – enter Ob

Semester 3

Obligatory courses / groups of courses Number of ECTS points 7

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/ group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ETD009588W	Sensors and Actuators	1					K2eit_W08 K2eit_W13 K2eit_U08	15	60	2	1,2	T	Z			K	Ob
2.	ETD009079W	Diagnostics and Reliability	1					K2eit_W07	15	30	1	0,6	T	Z			K	Ob
3.	ETD009079P	Diagnostics and Reliability				1		K2eit_U07 K2eit_K06	15	60	2	1,4	T	Z		P	K	Ob
4.	FLD129580W	Philosophy of Science and Technology	1					K2eit_K09 K2eit_K10 K2eit_K12	15	60	2	1,2	T	Z	O		KO	Ob
		Total	3	0	0	1	0		60	210	7	4,4						

Optional courses / groups of courses (255 hours in semester, 24 points ECTS)

No.	Course/group of courses code	Name of course/group of courses (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points		Form[2] of course/ group of courses	Way[3] of crediting	Course/group of courses			
			lec	cl	lab	pr	sem		ZZU	CNPS	total	BK classes[1]			university-wide[4]	practical[5]	kind[6]	type[7]
1.	ETD009585W	Packaging of EPM	1					S2epm_W14	15	30	1	0,6	T	Z			S	W
2.	ETD009585L	Packaging of EPM			2			S2epm_U16 S2epm_U17 S2epm_K07	30	30	1	0,7	T	Z		P	S	W

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

3.	ETD009586S	Diploma Seminar					2	K2eit_W01-K2eit_W12, S2epm_W01-S2epm_W14 K2eit_U01-K2eit_U16, S2epm_U01-S2epm_U19 S2epm_K01 S2epm_K03 S2epm_K05	30	60	2	1,4	T	Z		P	S	W
4.	ETD009581D	MSc Thesis Work				12		K2eit_W01-K2eit_W12, S2epm_W01-S2epm_W14 K2eit_U01-K2eit_U16, S2epm_U01-S2epm_U20 K2eit_K01-K2eit_K12, S2epm_K01-S2epm_K09	180	600	20	14	T	Z		P	S	W
		Total	1	0	2	12	2		255	720	24	16,7						

Altogether in semester:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Number of ECTS points for BK classes[1]
lec	cl	lab	pr	sem				
4	0	2	13	2	315	930	31	21,1

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

2. Set of examinations in semestral arrangement

Course / group of courses code	Names of courses / groups of courses ending with examination	Semester
MAT001449W ETD008564W ETD008565W	1. Mathematics 2. Optical Fibers 3. Vacuum and Plasma Techniques	1
ETD009584W ETD009582W	1. Advanced Optoelectronics 2. Ceramic Microsystems	2

3. Numbers of allowable deficit of ECTS points after particular semesters

Semester	Allowable deficit of ECTS points after semester
1	12
2	6

Opinion of student government legislative body

....
Date Name and surname, signature of student representative

....
Date Dean's signature

[1]BK – number of ECTS points assigned to hours of classes requiring direct contact of teachers with students
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of courses – after the letter E or Z - enter in brackets the final course form (lec, cl, lab, pr, sem)
[4]University-wide course /group of courses – enter O
[5]Practical course / group of courses – enter P. For the group of courses – in brackets enter the number of ECTS points assigned to practical courses
[6] KO – general education, PD – basic sciences, K – field-of-studies, S – specialization
[7] Optional – enter W, obligatory – enter Ob

FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name in Polish: Statistics for EPM
Name in English: Statistics for EPM
Main field of study (if applicable): Electronics and Telecommunications
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: obligatory
Subject code: ETD008081
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	15			
Number of hours of total student workload (CNPS)	30	60			
Form of crediting	crediting with grade	crediting with grade			
For group of courses mark final course with (X)					
Number of ECTS points	1	2			
including number of ECTS points for practical (P) classes		2			
including number of ECTS points for direct teacher-student contact (BK) classes	0,6	1,4			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basis knowledge of probability and mathematical analysis

SUBJECT OBJECTIVES

C1 Gaining the knowledge about the role of statistical methods in engineering and data collection methods
C2 Gaining the knowledge about such statistical methods like: descriptive statistics, point estimation, confidence intervals, hypothesis testing, analysis of variance, linear regression and correlation
C3 Coming the knowledge of the basis of statistical quality control
C4 Gaining the skill in practical problem solution with the aid of statistical methods
C5 Gaining students conscious of the necessity of application statistical methods in engineering

SUBJECT LEARNING OUTCOMES

Relating to knowledge:
PEU_W01 Holding the knowledge in the field of collection, analysis and presentation of statistical data
Relating to skills:
PEU_U01 Holding the ability to select and use suitable statistical tools for problem solving in engineering

Relating to social competences:
PEU_K01 Perceiving and understanding aspects connected with collection and presentation

	of data in different domains of engineering and necessity of application of statistics

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec1	Introduction. Rules. Course contents.	1
Lec2	Probability and types of probability distributions.	2
Lec3	The role of statistics in engineering.	1
Lec4	Descriptive statistics.	3
Lec5	Point and interval estimation.	2
Lec6	Linear regression and correlation. Hypothesis testing.	3
Lec7	Statistical quality control	2
Lec8	Writing test	1
	Total hours	15

Project		**Number of hours**
Cl1	Introduction. Rules. Course contents.	1
Cl2	Solving examples of application of selected probability distributions.	2
Cl3	Solving examples of basis statistical calculations.	2
Cl4	Application of descriptive statistics in engineering – solving examples.	3
Cl5	Point estimation and statistical intervals – solving examples.	3
Cl6	Linear regression and correlation – solving examples	2
Cl7	Workout classes	2
Cl8	Total hours	15

TEACHING TOOLS USED
N1. Lecture with multimedia presentation and discussion. N2. Consultations. N3. Students' own work: get ready for the lecture. N4. Students' own work: get ready for classes N5. Students' own work: independent solution of work tasks during classes. N6. Classes: short 15 minutes tests at the beginning of the lessons.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1=F1 (Lecture)	PEU_W01	Positive mark from writing test
F2 (Classes)	PEU_U01	Short tests
F3 (Classes)	PEU_U01	Ability to solving problems during classes
P2 (Classes) = 0.5F3+0.5F2	PEU_U01	Positive average weighed mark from short test and ability to solving problems during classes

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] [1] R. Lyman Ott, Michael Longnecker, An introduction to statistical methods and data analysis, Brooks/Cole Cemgage Learning, 6th, Ed., 2010
[2] Roman Nowak, Statystyka dla fizyków, PWN, 2002

SECONDARY LITERATURE:

[1] Dr. Graham Currell, Dr. Antony Dowman, Essential Mathematics and Statistics for Science, 2nd Edition, Wiley, 2009
[2] S. J. Morrison, Statistics for Engineers: An Introduction, Wiley, 2009

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Numerical Methods
Name of subject in English: Numerical Methods
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): N/A
Profile: academic
Level and form of studies: 2nd level / full-time studies
Kind of subject: obligatory / university-wide
Subject code: ETD008082
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		30		
Form of crediting	crediting with grade		crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BK) classes	0,6		1,4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge on basics of mathematics and physic
2. Knowledge on basics of computer programming
3. Basic computer skills

SUBJECT OBJECTIVES

C1 To familiarize students with the basic numerical algorithms and methods used in engineering including restrictions, disadvantages and advantages of numerical techniques. In addition, gaining skills in using the Python scripting language
C2 Consolidation ability to work independently and in collaboration with the available educational materials
C3 The course is connected with the research activities in the area of numerical prototyping
C4 Application of numerical methods for solving simple engineering problems
C5 Participation of the students in the carried out research in numerical prototyping

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 Has a basic, orderly and theoretically founded knowledge on the numerical methods used in engineering. The scope of knowledge includes an analysis of errors, methods, numerical differentiation and integration, solving systems of linear and nonlinear equations, interpolation and approximation methods, algorithms, single- and multicriteria optimization and design of experiments

methods

PEU_W02 Knows and understands the basic numerical methods and tools for solving typical engineering problems

Relating to skills:

PEU_U01 Is able to select and apply in a practical way right tools, programs, methods and numerical algorithms to solve typical problems in the field of numerical prototyping in engineering. Additionally, is able to interpret the results, and use the appropriate methods for validation of measurement results

PEU_U02 Student is able to plan experiments and numerical simulations including interpretation of the acquired results and draw conclusions

Relating to social competences:

PEU_K01 Can appropriately define the priorities for implementation of specified tasks

PEU_K02 Can properly distinguished and understand technical and none technical aspects of a contemporary engineering

PROGRAM CONTENT

Lectures		**Number of hours**
Lec1	Introduction to numerical methods and Python scripting language	2
Lec2	Numerical computing	2
Lec3	Numerical differentiation and integration	2
Lec4	Linear and nonlinear equations and set of equations	2
Lec5	Interpolation, approximation and extrapolation	2
Lec6	Optimization, design of experiments and data interpretation	2
Lec7	Numerical methods for solving partial differential equations	2
Lec8	Final test	1
	Total hours	15

Laboratory		**Number of hours**
Lab1	Introduction to numerical methods and engineering computing with Python programming language	2
Lab2	Numerical computing errors - sources and types	2
Lab3	Numerical differentiation and integration	2
Lab4	Linear and nonliner equations and set of equations	2
Lab5	Interpolation, approximation and extrapolation	2
Lab6	Optimization and design of experiments	2
Lab7	Partial differential equations	2
Lab8	Individual project / Assessment	1
	Total hours	15

TEACHING TOOLS USED

N1. Traditional lecture with multimedia presentations and discussion
N2. Laboratory: 5-minutes introduction and 5-minutes introductory tests
N3. Consultation
N4. Individual work: preparation for lecture
N5. Individual work: preparation for laboratories
N6. Individual work: literature study and preparation for the final test

N7. Individual work: laboratory reports

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01, PEU_W02	Discussions and final test
F2 (laboratory)	PEU_U01, PEU_U02, PEU_K01, PEU_K02	Laboratory tests and quizzes, lab reports
P=F1+F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] FEYNMANN R.P., FEYNMANA WYKŁADY Z FIZYKI, TOM I I II, PWN, 1968
[2] Janowski W., Matematyka, tom I i II,, PWN,, 1968
[3] Volk W., Statystyka stosowana dla inżynierów, WNT, 1973

SECONDARY LITERATURE:

[1] KREYSZIG E., ADVANCED ENGINEERING MATHEMATICS, JOHN WILEY AND SONS, 2006
[2] Montgomery D., Design and Analysis of Experiments, John Wiley and Sons, 2005
[3] Pang T., An Introduction to Computational Physics, Cambridge University Press, 2006

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Optimization Methods**	
Name in English:	**Optimization Methods**	
Main field of studies:	**Electronics and Telecommunications**	
Specialization:	**N/A**	
Level and form of studies:	**II level**	**/ Full time**
Kind of subject:	**Obligatory**	**/ Faculty**
Subject code:	**ETD008083**	
Group of courses:	**NO**	

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	15			
Number of hours of total student workload (CNPS)	30	60			
Form of crediting	Z	Z			
Number of ECTS points	1	2			
Including number of ECTS points for practical (P) classes	0	2			
Including number of ECTS points for direct teacher-student contact (BK) classes	0.6	1.4			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of mathematics in the range of mathematical analysis and linear algebra
2. Credit of course: Mathematical analysis I
3. Credit of course: Algebra with analytical geometry

SUBJECT OBJECTIVES

C01 To acquaint students with the basic of optimization methods
C02 To gain skills of solution of simple problems dealing with optimization by means of different methods
C03 To understand need of application of optimization methods in practical engineering

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 He has theoretical knowledge and he understands different methods solution of linear and non-linear optimization problems

Relating to skills

PEU_U01 He is able to solve simple problems in the range of optimization by means of different methods

Relating to social competences

PEU_K01 He understands utilization of optimization methods in technical activity

PROGRAMME CONTENT

Form of classes - Lecture		Quantity
Le_01	General problems of linear programming	2
Le_02	Simplex method	2
Le_03	Method of artificial base.	2
Le_04	Dual problem	2
Le_05	Non-linear programming, non-gradient methods	2
Le_06	Gradient methods	2
Le_07	Constrained non-linear optimization	2
Le_08	Test	1
	TOTAL	15

Form of classes - Classes		Quantity
Cl_01	Solving of problems in the range of matrix algebra, solving of linear equations sets	2
Cl_02	Graphical method for solution of linear optimization problems	2
Cl_03	Simplex method for solution of linear optimization problems	2
Cl_04	Artificial base method for solution of linear optimization problems	2
Cl_05	Non-gradient methods for solution of non-linear optimization problems	2
Cl_06	Gradient methods for solution of non-linear optimization problems	2
Cl_07	Solving of constrained non-linear optimization problems	2
Cl_08	Test	1
	Total	15

TEACHING TOOLS USED

ND_01 Traditional lecture
ND_02 Classes- solving of problems connected with optimization methods
ND_03 Tutorials
ND_04 Individual work - studies for the lecture
ND_05 Individual work - studies of examples and exercises for classes
ND_06 Individual work - individual studies for test

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Credit test
P2 = F2 (classes)	PEU_U01, PEU_K01	Discussion, solving of problems, credit test

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. K. Amborski, Podstawy metod optymalizacji, Ofic. Wyd. Pol. Warszawa, 2009
2. S.I. Gass, Programowanie liniowe, PWN, 1973

Secondary literature

1. B. Martos, Programowanie nieliniowe, PWN, 1983

SUBJECT SUPERVISOR

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Solid state electronics
Name of subject in English: Solid state electronics
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): N/A
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: obligatory
Subject code: ETD008084
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	60				
Form of crediting	crediting with grade				
For group of courses mark final course with (X)					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes	0				
including number of ECTS points for direct teacher-student contact (BK) classes	1,2				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of higher mathematics for understanding the issues in physics and quantum electronics
2. Completing the course Physics I

SUBJECT OBJECTIVES

C1 The acquisition of knowledge in the theoretical description of free and bound states of the electron in the solid and the band theory
C2 Learning the theoretically founded issues relating to physical phenomena occurring in the solid and their applicability
C3 Familiarizing with the existing models of the structure of matter

SUBJECT LEARNING OUTCOMES

Relating to knowledge:
PEU_W01 Has knowledge of the theoretical description of the electron in the solid
PEU_W02 Has structured and theoretically founded knowledge on the phenomena occurring in the solid
PEU_W03 Knows and understands the principle of operation of various types of quantum computers
PEU_W04 Has knowledge on the structure of the matter according to the current model

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec1	Electrons inside crystal. Brillouin zones	2
Lec2	Kronig – Penney model - part I	2
Lec3	Kronig – Penney model - part II	2
Lec4	Photoelectron effect	2
Lec5	Acoustical-electronic phenomena	2
Lec6	Piezoelectric effect	2
Lec7	Superconductivity effect	2
Lec8	High-temperature superconductivity	2
Lec9	Spintronics	2
Lec10	Electronics of single electron	2
Lec11	Quantum computation - part I	2
Lec12	Quantum computation - part II	2
Lec13	Material constitution according to Standard Model	2
Lec14	Higgs theory	2
Lec15	Test	2
	Total hours	30

TEACHING TOOLS USED
N1. Traditional lecture with presentations and discussion N2. Student's own work N3. Consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01-PEU_W04	Writing test

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Chih-Tang Sah, Fundamentals of solid-state electronics, World Scientific, London, 1991
[2] Tinkham M., Introduction to superconductivity, Dover Publications, Inc. Mineola, New York, 1996
[3] Levine S.N., Fizyka kwantowa w elektronice, PWN, W-wa 1968
[4] Ashcroft M., Mermin W., Fizyka ciała stałego, PWN, W-wa, 1986

SECONDARY LITERATURE:

[1] Boncz-Brujewicz W., Kałasznikow S., Fizyka półprzewodników, PWN, W-wa, 1985
[2] Kittel C., Wstęp do fizyki ciała stałego, PWN, W-wa 1976

[3] Van der Ziel A., Podstawy fizyczne elektroniki ciała stałego, WTN, W-wa, 198

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Nanotechnology
Name of subject in English: Nanotechnology
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): N/A
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: obligatory
Subject code: ETD008085
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				30
Number of hours of total student workload (CNPS)	30				60
Form of crediting	crediting with grade				crediting with grade
For group of courses mark final course with (X)					
Number of ECTS points	1				2
including number of ECTS points for practical (P) classes	0				2
including number of ECTS points for direct teacher-student contact (BK) classes	0.6				1.4

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of fundamentals of physics and chemistry
2. Knowledge of fundamentals of solid state physics
3. Passed an examination of "Semiconductor devices II" course
4. Passed an examination of "Electronics devices and circuits" course
5. Passed an examination of "Optoelectronics" course

SUBJECT OBJECTIVES

C1 Presentation of Nanotechnology as an technical science which couples many fields of activities like: material science, chemistry, physics computer science and biology, which connected together allows fabrication of advanced structures useful in a common life

C2 Presentation of profits coming from taking advantages of new phenomena or unique properties of matter which are the results of size reduction

C03 Make Students familiar with fundamentals of processes and physico-chemical phenomena used for fabrication of nanostructures and nanoobjects

C04 Presentation of constructions of molecular electronic devices and discussion of influence of atomic structure of the material on their properties

C05 Improvement of the skills of expression and discussion in the range of scientific fields

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 It has an expanded and enhanced knowledge of the physics, including quantum physics, solid state physics and necessary knowledge for understanding physical phenomena which influence the properties of new materials and principles of working of optoelectronic devices

Relating to skills:

PEU_U01 Can evaluate and use phenomena proceed in solid state materials for quantum electronics applications purposes

Relating to social competences:

PEU_K01 It will be openness to new innovative solutions, structures and manufacturing processes

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec1	Introduction to Nanotechnology -definition, development direction and application fields.	2
Lec2	Molecular electronic devices. Drexler's and Feynman's worlds.	2
Lec3	Nanoelectronics - Two- and one- dimensional electron gas (2DEG and 1DEG) properties. Carrier transport, ballistic carrier transport in low dimensional structures. Hall effect and quantum Hall effect. Quantum wire transistor and single electron transistor - construction, operation rules.	4
Lec4	Principle of operation and construction of semiconductor devices containing low dimensional structures. Quantum size effects and their influence on properties of objects/devices. Self assembled structures -properties and technology. Properties of semiconductor devices with QD/Qdash/MQW (Quantum Dot/Quantum Dash/Multi Quantum Well) active regions. Modification of properties of semiconductor heterostructures during selective oxidation and rapid thermal annealing.	3
Lec5	Influence of intermolecular interaction on properties of semiconductor heterostructures. Modification of band diagram of semiconductors by presence of defects, stresses and interstitial positions of atoms in crystal lattice. Consequences of rapid thermal annealing -short range order. Techniques of epitaxy of self-organizing structures.	3
Lec6	Final test	1
	Total hours	15

Seminar		**Number of hours**
Se1	Introducing; discussion of the subjects chosen by the students for individual elaboration.	2
Se2	Oral presentations performed by students which deal with a subject presented during lectures or new subjects proposed by teacher or students referring to semiconductor Nanotechnology or Nanotechnology of opto- and microelectronics devices, opened discussions to each	26

	presented topics in order to precise explanation of the discussed issues. Small tests during semester.	
Se3	Visit in the Laboratory for Optical Spectroscopy of Nanostructures - depending on the seminar schedule.	2
	Total hours	30

TEACHING TOOLS USED
N1. Traditional lecture supported by the multimedial presentation, discussion and exhibition of chosen semiconductor devices.
N2. Seminar: Oral presentations of selected subjects performed by students with discussion and comments of teacher, Two 10 min long tests in semester, Visit in the Laboratory for Optical Spectroscopy of Nanostructures.
N3. Consultation hours.
N4. Individual work - preparation of the oral presentation and chosen subjects for discussion
N5. Individual work - education including preparation for final test.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01	Final test during the last lecture
F2 (seminar)	PEU_U01 PEU_K01	Average grade dependent on the oral presentation, small tests and participation in discussion.
P (lecture) = F1		
P (seminar) = F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] *Springer Handbook of Nanotechnology*, Bharat Bhushan Editor, Springer-Verlang Berlin Heidelberg 2004

[2] J. C. Ellenbogen, J. Christopher Love, *Architectures for Molecular Electronic Computers: 1. Logic Structures and an Adder Designed from Molecular Electronic Diodes*, lipiec 1999

[3] J. H. Davies, A. R. Long, *Physics of Nanostructures*, Proceedings of the Thirty-Eighth Scottish Universitates Summer School in Physics St Andrews, 1991

[4] R. Eisberg, R. Resnick, *Fizyka Kwantowa atomów, cząsteczek, ciał stałych, jąder i cząsteczek elementarnych*, PWN, Warszawa 1983

[5] C. Joachim, J. K. Gimzewski, A. Aviram, Electronics using hybrid-molecular and mono-molecular devices, Nature, vol 408, 30 November 2000

[6] D. Goldhaber-Gordon, Michael S. Montemerlo, J. Christopher Love, Gregory J. Opiteck, James C. Ellenbogen, *Overview of nanoelectronic devices*, The Procedings of the IEEE, April 1997

[7] Kenneth J. Klabunde, Nanoscale Materials in Chemistry, Wiley, 2001

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

[9] Pallab Bhattacharya, *Semicondudtor Optoelectronic Devices*, *Second Edition*, Prentice

Hall New Jersey 1997

SECONDARY LITERATURE:

[1] D. Pucicki, *Badanie kinetyki wzrostu heterostruktur $In_yGa_{1-y}As_{1-x}N_x/GaAs$ przeznaczonych do konstrukcji przyrządów optoelektronicznych*, rozprawa doktorska, P.Wr. 2006

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Optical Fibers**
Name in English:	**Optical Fibers**
Main field of studies:	**Electronics and Telecommunications**
Specialization:	**Electronics, Photonics, Microsystems**
Level and form of studies:	**II level / Full time**
Kind of subject:	**Optional / Faculty**
Subject code:	**ETD008564**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	60		60		
Form of crediting	E		Z		
Number of ECTS points	2		2		
Including number of ECTS points for practical (P) classes	0		2		
Including number of ECTS points for direct teacher-student contact (BK) classes	1.2		1.4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of physics and optics
2. Fundamental knowledge of optical fibers

SUBJECT OBJECTIVES

C01 A reminder of fundamental knowledge of fiber optics
C02 Acquiring knowledge and skills allowing for correct selection of optical-waveguide components necessary to build optical-fiber systems
C03 Acquiring knowledge and skills necessary for measurements of fiber-optic components
C04 Acquiring knowledge on the most important optoelectronic components interacting with optical fibers
C05 Acquiring advanced expertise knowledge about different elements of fiber-optic communication path
C06 Mastering the skills of work with photonic elements and measurement instruments of optical-fiber technique
C07 Participation of the students in the carried out research in optical fibers technique

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 Has well-organized and theoretically founded knowledge in the field of photonics, including knowledge necessary to understand physical fundamentals of operation of optical telecommunication systems and optical recording and information processing

Relating to skills

PEU_U01 Knows and applies the principles of occupational health and safety when working with lasers and optical fibers. Can operate measurement instruments and assemble measurement systems in the field of photonics

Relating to social competences

PEU_K01 Works independently and in a team

PROGRAMME CONTENT

Form of classes - Lecture		Quantity
Le_01	Introduction - summary of basic knowledge about optical fibers	2
Le_02	Analysis of optical-fibers with methods of wave optics	2
Le_03	Fundamental properties of optical-fibers in the light of international standards	2
Le_04	Measurements of basic properties of optical fibers	2
Le_05	Dispersion of optical fibers	2
Le_06	Methods of optical-fiber dispersion measurements and compensation	2
Le_07	Connections of optical fibers and cables (spliced connectors)	2
Le_08	Connections of optical fibers and cables (dismountable connectors)	2
Le_09	Optical Time Domain Reflectometer	2
Le_10	Specialty fiber optic components (fiber-optic Bragg gratings, multiplexers, optical amplifiers)	2
Le_11	Multimode optical fibers	2
Le_12	Introduction to fiber-optic WDM systems	2
Le_13	Classification and characterization of fiber-optic telecommunication lines	2
Le_14	Elements of nonlinear optics and soliton transmission	2
Le_15	Colloquium, repertory and sample test	2
	TOTAL	30

Form of classes - Laboratory		Quantity
La_01	Fiber splicing by fusion in an electric arc	4
La_02	Preparation of ST fiber-optic connectors	4
La_03	Measurements of spectral characteristics of optical fibers	4
La_04	Passive elements of fiber-optic track (fiber-optic coupler and circulator	4
La_05	Measurements of optical-fiber lines by the direct method and with optical reflectometer	4
La_06	Measurement of refractive index distribution in optical fiber	4
La_07	Study of the impact of fiber attenuation on fiber-optic line distance	2
La_08	Study of the impact of dispersion on fiber-optic line distance	4
	Total	30

TEACHING TOOLS USED
ND_01 Classical lecture with presentations and discussion
ND_02 Lecture supported with e-learning tools
ND_03 Laboratory: short tests and the beginning of classes, exercises to be performed in a group
ND_04 Own work - preparation of selected issues for the lecture
ND_05 Own work - preparation for the lab exercises.
ND_06 Own work - self-study and preparation for the colloquium
ND_07 Consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	The average of tests, colloquium and final examination
P2 = F2 (lab)	PEU_U01, PEU_U02	Discussions, consultations, quizzes

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. Marciniak M., Łączność światłowodowa, WKŁ, 1998

Secondary literature

1. Siuzdak J., Wstęp do współczesnej telekomunikacji światłowodowej, WKŁ, 1997

SUBJECT SUPERVISOR

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Autonomous Power Supplying Systems**	
Name in English:	**Autonomous Power Supplying Systems**	
Main field of studies:	**Electronics and Telecommunications**	
Specialization:	**Electronics, Photonics, Microsystems**	
Level and form of studies:	**II level**	**/ Full time**
Kind of subject:	**Optional**	**/ Faculty**
Subject code:	**ETD008566**	
Group of courses:	**NO**	

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	60				
Form of crediting	Z				
Number of ECTS points	2				
Including number of ECTS points for practical (P) classes	0				
Including number of ECTS points for direct teacher-student contact (BK) classes	1.2				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

No requirements

SUBJECT OBJECTIVES

C01 Presentation of rules of power supplying of autonomous electronic devices and microsystems
C02 Review of technical realisations and properties of energy harvesting methods and devices

SUBJECT LEARNING OUTOCMES

Relating to knowledge

PEU_W01 Has detailed knowledge connected with physics and basics of chemistry necessary to understand operation of power supplying systems co-working with microsystems (principle of operation, technological and technical realisations, main parameters)

PROGRAMME CONTENT		
Form of classes - Lecture		Quantity
Le_01	Energy balance in microsystems	2
Le_02	Rules of microsystem power supplying	2
Le_03	Photovoltaic effect, solar cells	2
Le_04	Technical realisations and operation parameters of solar microcells and micromodules	2
Le_05	Thermoelectric phenomena	2
Le_06	Thermoelectric microgenerators - technical realisations and main operation parameters	2
Le_07	Direct and inversed piezoelectric effect	2
Le_08	Piezoelectric microgenerators - technical realisations and main operation parameters	2
Le_09	Fuell cels - pricniples of operation	2
Le_10	Microfuel cells - technological and construction realisations	2
Le_11	Mechanical energy microgenerators	2
Le_12	Rules of energy storage	2
Le_13	Batteries and accumulators for microsystems- technical realisations and main parameters	2
Le_14	Sources of energy - global issues	2
Le_15	Colloquium	2
	TOTAL	30

TEACHING TOOLS USED
ND_01 Lectures with presentations and discussions ND_02 Own work - preparation to the colloquium

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Test

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. D.M. Rove, Handbook of Thermoelectrics, CRC Press, 1996
2. W. Ehrefeld, Microreactors - new technology for modern chemistry, Wiley-Vch Verlag, 2000

Secondary literature

1. Articles in scientific journals – choosen by the lecturer

SUBJECT SUPERVISOR

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Vacuum and Plasma Techniques
Name of subject in English: Vacuum and Plasma Techniques
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): Electronics, Photonics, Microsystems
Profile: academic / general academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: optional / university-wide
Subject code: ETD008568
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	30				
Form of crediting	Examination				
For group of courses mark final course with (X)					
Number of ECTS points	1				
including number of ECTS points for practical (P) classes	0				
including number of ECTS points for direct teacher-student contact (BK) classes	0,6				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Credit for physics course

SUBJECT OBJECTIVES

C1 Understanding the phenomena under reduced pressure (vacuum)
C2 Possession of knowledge about the application of modern vacuum techniques (methods of generation and measuring vacuum)
C3 Gain knowledge about the role of vacuum in microelectronic technologies

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 He has knowledge of the phenomena occurring at low gas pressure and of the action of vacuum (vacuum production and measurement) in the context of the technological processes used in microelectronics

PROGRAM CONTENT

Lectures		**Number of hours**
Lec1	Introduction. Basic definitions. Elements of the kinetic theory of gases	3
Lec2	Gas flow (gas throughput, pumping speed)	1
Lec3	Backing (pre-vacuum) pumps – oil sealed vacuum pumps (wet pumps)	2

Lec4	Backing (pre-vacuum) pumps – dry pumps	2
Lec5	High vacuum transfer pumps (diffusion, turbomolecular pumps).	3
Lec6	High vacuum sorption pumps (ion, sublimation, cryo, getter pumps)	3
Lec7	Vacuum measurement using direct and indirect vacuum gauges. Lab lecture - visit at the vacuum lab, demonstration of the pumping process, vacuum main parameters	4
Lec8	Partial pressure vacuum gauges – mass spectrometers	1
Lec9	Modern vacuum – MEMS in vacuum systems	1
Lec10	Thin film vacuum deposition processes (evaporation, sputtering)	1
Lec11	Plasma – abnormal discharge. Classification of discharges	1
Lec12	Basic processes in the discharge. Movement of electrons and ions in rarefied gas during deposition process	1
Lec13	Ion sputtering. Ion plating. Ion implantation. Ion cleaning	1
Lec14	Principles of the vacuum systems design. The role of vacuum parameters during thin film deposition. Scheme of the vacuum process. Lab-lecture – visit at the vacuum lab, demonstration of thin film deposition process using magnetron sputtering (metallization, compound film obtaining during reactive process)	4
Lec15	Summary, course completion	2
	Total hours	30

TEACHING TOOLS USED
N1. Traditional lectures and interactive presentations supported elements of the assessment N2. Own work - consultation N3. Presentation of the vacuum laboratory – standard vacuum technology and technique (vacuum parameters, vacuum deposition process of thin films)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1=F1 (lecture)	PEU_W01	Interactivity during a lecture, colloquium, oral exam

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J.O'Hanlon, A user's Guide to Vacuum Technology, Wiley-Interscience, (third edition), 2003
[2] M. Wutz, H. Adam, W. Walcher Theory and Practice of Vacuum Technology, Friedr.Vieweg & Sohn, Braunschweig 1989
[3] N. Harris, Modern Vacuum Practice , self-published, (third edition), 2005
[4] W.Posadowski, lecture

SECONDARY LITERATURE:

[1] Andrzej Hałas Technologia Wysokiej Próżni, PWN W-wa 1980
[2] Andrzej Hałas, Piotr Szwemin, Podstawy Techniki Próżni, Uczelniane Wydawnictwo

Naukowo-Dydaktyczne, Kraków, 2008
[3] Janusz Groszkowski, Technika Wysokiej Próżni, WNT W-wa 1978

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Diagnostics and Reliability**	
Name in English:	**Diagnostics and Reliability**	
Main field of studies:	**Electronics and Telecommunications**	
Specialization:	**N/A**	
Level and form of studies:	**II level**	**/ Full time**
Kind of subject:	**Obligatory**	**/ Faculty**
Subject code:	**ETD009079**	
Group of courses:	**NO**	

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	30			60	
Form of crediting	Z			Z	
Number of ECTS points	1			2	
Including number of ECTS points for practical (P) classes	0			2	
Including number of ECTS points for direct teacher-student contact (BK) classes	0.6			1.4	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of mathematics fundamentals in the range of mathematical analysis, probabilistics and statistics
2. Credit of course: Mathematics analysis I
3. Credit of course: Probability and statistics

SUBJECT OBJECTIVES

C01 To acquaint students with the problems dealing with diagnostics and reliability of components and electronic devices

C02 To gain skills necessary for analysis of problems connected with failure and reliability of components and electronic devices

C03 To understand the purpose of knowledge application in reliability analysis of components and devices

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 He has knowledge dealing with reliability theory, testing and diagnostics as well as failure models

Relating to skills

PEU_U01 He is able to solve independently the problems connected with reliability, failure diagnostics and measurement data analysis

Relating to social competences

PEU_K01 He understands the need of mathematics application in order to analyse technical problems

PROGRAMME CONTENT

Form of classes - Lecture		Quantity
Le_01	Reliability of binary systems	2
Le_02	Systems structures- functions describing reliability	2
Le_03	Simulation models of reliability	2
Le_04	Selective tests	2
Le_05	Failure mechanisms of electronic components	2
Le_06	Reliability models	2
Le_07	Influence of operating conditions on reliability	2
Le_08	Final test	1
	TOTAL	15

Form of classes - Project		Quantity
Pr_01	Distribution of individual project exercises, description of subject-matter and conditions of project realization	2
Pr_02	Discussion of problems connected with graphical presentation of measurement results concerning reliability	2
Pr_03	Discussion of problems connected with application of numerical methods in projects	2
Pr_04	Discussion of Monte Carlo method used in realization of projects	2
Pr_05	Discussion of problems connected with prognosis of devices reliability depending on operating conditions	2
Pr_06	Presentation of individual project realization, discussion	2
Pr_07	Presentation of individual project realization, discussion	2
Pr_08	Collecting of students project, presentation of results	1
	Total	15

TEACHING TOOLS USED

ND_01 Traditional lecture
ND_02 Project - individual solving of project in the range of reliability, discussion of problems dealing with project realization
ND_03 Tutorials
ND_04 Individual work - studies for lectures
ND_05 Individual work - individual studies and tasks connected with project realization
ND_06 Individual work - individual studies for tests

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Final test
P2 = F2 (project)	PEU_U01, PEU_K01	Discussion, independent solution of project

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. F. Grabski, J. Jaźwiński, Funkcje o losowych argumentach w zagadnieniach niezawodności, bezpieczeństwa i logistyki, WKŁ, 2009
2. H. Gładysz, E. Peciakowski, Niezawodność elementów elektronicznych, WKŁ, 1984

Secondary literature

1. Grabski, J. Jaźwiński, Metody bayesowskie w niezawodności i diagnostyce, WKŁ, 2001
2. S. Firkowicz, Statystyczne badanie wyrobów, WNT, 1970

SUBJECT SUPERVISOR

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Optical-Fiber Networks**
Name in English:	**Optical-Fiber Networks**
Main field of studies:	**Electronics and Telecommunications**
Specialization:	**Electronics, Photonics, Microsystems**
Level and form of studies:	**II level / Full time**
Kind of subject:	**Optional / Faculty**
Subject code:	**ETD009571**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	30			30	
Form of crediting	Z			Z	
Number of ECTS points	1			2	
Including number of ECTS points for practical (P) classes	0			2	
Including number of ECTS points for direct teacher-student contact (BK) classes	0.6			1.4	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of optical networks
2. Basic knowledge of optical fibers

SUBJECT OBJECTIVES

C01 Clearing and organizing fundamental knowledge on optical fibers and computer networks
C02 Familiarizing students with basics of optical networks operation
C03 Providing students with knowledge suitable for design of optical-fiber networks.
C04 Familiarizing students with the current state of knowledge in the field of operation of optical networks
C05 Providing students with the knowledge about network design and acquiring by students skills for useful for working in the organized groups
C06 Acquiring knowledge and research skills to design and build optical fiber networks

SUBJECT EDUCATIONAL EFFECTS

Relating to knowledge

PEU_W01 Has in-depth knowledge in the field of photonics, including the knowledge necessary to understand operation of telecommunications systems and optical recording and processing of information

Relating to skills

PEU_U01 Can choose and evaluate optical-fiber and optoelectronic elements used for construction of photonic and optical network systems

Relating to social competences

PEU_K01 Can develop a plan to implement a project, can interact and work in a group, accepting different roles in the group

PROGRAMME CONTENT

Form of classes - Lecture		Quantity
Le_01	Introduction to optical networks	2
Le_02	Optical Ethernet - 10M and 100M	2
Le_03	Optical Ethernet - 1G	2
Le_04	10G Optical Ethernet, and beyond	2
Le_05	Design and measurements procedures of optical networks	2
Le_06	WDM networks and all-optical network of the future	2
Le_07	RAINBOW - an example of all optical network	2
Le_08	Final test	1
	TOTAL	15

Form of classes - Project		Quantity
Pr_01	Optical Fiber Network design methodology	2
Pr_02	Determination of design requirements for a small LAN network	2
Pr_03	Preparation of maps and plans of the network localization	2
Pr_04	Selection and analysis of fiber-optic network equipment	4
Pr_05	Calculation of the balance of power for the designed network	2
Pr_06	Preparation of the final version of the project	3
	Total	15

TEACHING TOOLS USED

ND_01 Traditional lecture with presentations and discussion
ND_02 Lecture supported with e-learning tools
ND_03 Project: independent development by students of reports describing results of their work
ND_04 Project: independent search and analysis of data about components and devices.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Consultations, on-line tests, final test
P2 = F2 (project)	PEU_U01, PEU_K01	Evaluation of the entire project based on the evaluation of partial stages

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. Vademecum Teleinformatyka cz. I, IDG, 2004

Secondary literature

1. Vademecum Teleinformatyka cz. III, IDG, 2004
2. Vademecum Teleinformatyka cz. II, IDG, 2002

SUBJECT SUPERVISOR

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Operating Systems**
Name in English:	**Operating Systems**
Main field of studies:	**Electronics and Telecommunications**
Specialization:	**Electronics, Photonics, Microsystems**
Level and form of studies:	**II level / Full time**
Kind of subject:	**Optional / Faculty**
Subject code:	**ETD009572**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	Z		Z		
Number of ECTS points	1		2		
Including number of ECTS points for practical (P) classes	0		2		
Including number of ECTS points for direct teacher-student contact (BK) classes	0,6		1,4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Completed the course material: Introduction to computer science OR Computer science

SUBJECT OBJECTIVES

C01 Gaining theoretical knowledge referred to in Le_01-Le_07
C02 Gaining practical skills through laboratory tasks La_01-La_07

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 Has ordered knowledge of the principles of operation and programming of operating systems, including embedded systems

Relating to skills

PEU_U01 He can use, configure and program applications for different operating systems, including embedded

Relating to social competences

PEU_K01	Able to interact and work in a group of laboratory, taking in the different roles

PROGRAMME CONTENT		
Form of classes - Lecture		Quantity
Le_01	Real Time Operating System (RTOS) architecture and implementations	2
Le_02	Filesystems. FAT, NTFS, ext2 overview. Hard link and soft links, rights, data encryption, mounting and unmounting	2
Le_03	Programming mobile applications for Android	2
Le_04	Overview of Linux and Windows based operating systems. OS kernel functions. Mobile operating systems	2
Le_05	Memory management: virtual memory; paging and segmentation; protected mode; page descriptors	2
Le_06	Kernel-level process synchronization. Scheduler. Process states and transitions.	2
Le_07	Inter-process data exchange in Windows and Linux. Shared memory, signals, messages, pipes	2
Le_08	Final test	1
	TOTAL	15

Form of classes - Laboratory		Quantity
La_01	Introduction. Configuring VirtualPC / VBOX. Portability of ANSI C source code: a console application on Linux and Windows, the standard input / output in these systems	2
La_02	InterNICHE or MQX RTOS for ColdFire: Implementation of multi-tasking	2
La_03	Using threads and event-driven application in Windows. Selected elements of the subsystem WinAPI	2
La_04	Basics of Linux. Manage permissions, using shell scripting, mounting file systems	2
La_05	Process management in Linux system and interprocess data exchange	2
La_06	Preparation and launch of Android image for a development board	2
La_07	Design application for Android to control your device or model of intelligent building	2
La_08	Additional (spare) classes	1
	Total	15

TEACHING TOOLS USED	
ND_01	The traditional lecture with presentations and discussion
ND_02	Program completion quizzes to verify the current curriculum
ND_03	Consultation
ND_04	Specialized software and electronic kits
ND_05	Self study - preparation of selected topics in the lecture
ND_06	Self study - preparation of selected topics in the laboratory

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Discussions and final test
P2 = F2 (lab)	PEU_U01, PEU_K01	Laboratory tests and quizzes, lab reports

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. Friesen, Geoff, Java: przygotowanie do programowania na platformę Android , Helion, 2012
2. Silberschatz, Abraham, Operating system concepts, John Wiley & Sons, 2010
3. Tanenbaum, Andrew S., Modern operating systems, Pearson Prentice Hall, 2009
4. Tanenbaum, Andrew S., Systemy operacyjne, Helion, 2010

Secondary literature

1. Barry, Richard, Using the FreeRTOS real time kernel : ARM Cortex-M3 edition, Real Time Engineers, 2010

SUBJECT SUPERVISOR

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Photovoltaics
Name of subject in English: Photovoltaics
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): Electronics, Photonics, Microsystems
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: optional
Subject code: ETD009574
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	60		60		
Form of crediting	Exam		crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes	0		2		
including number of ECTS points for direct teacher-student contact (BK) classes	1,2		1,4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge on physics of semiconductor, in particular interaction between light and solid semiconductor (optoelectronics)
2. Basic knowledge on electronics, construction and manufacturing technology of semiconductor devices

SUBJECT OBJECTIVES

C1 Getting knowledge on operation principles, construction and manufacturing of photovoltaic devices cells and modules
C2 Getting knowledge on basic manufacturing methods, characterization methods of phtovoltaic devices and systems
C3 Getting knowledge on design, construction, installation and assessment rules of photovoltaic systems
C4 Getting information on basic technical standards and best practice guidelines in photovoltaics
C5 Participation of the students in the carried out research in photovoltaics

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 Acquiring basic, theoretically supported, knowledge about photovoltaic solar energy conversion, including understanding of physical basics of operation principles of photovoltaic devices, photovoltaic technologies, design and performance evaluation of photovoltaic systems

Relating to skills:

PEU_U01 Ability to perform measurements, correctly evaluate basic parameters of photovoltaic devices, prepare assumptions and make simple design of photovolatic system, predict expected electrical energy yield

Relating to social competences:

PEU_K01 Ability of working and collaborating in laboratory group, taking various roles, performing both measurement as well as more advanced project tasks

PROGRAM CONTENT

Lecture		**Number of hours**
Lec1	Introduction. Solar Energy resources	2
Lec2	Photovoltaic energy	2
Lec3	Construction and principle of operation of a photovoltaic cell	2
Lec4	Basic solar cell parameters and factors limiting its efficiency	2
Lec5	Silicon solar cell manufacturing technology	2
Lec6	Review of a new type of cells - their pros and cons	2
Lec7	Defects in solar cells and diagnostic methods	3
Lec8	Photovoltaics in social and economic terms	1
Lec9	Solar systems for IoT	2
Lec10	Solar concentrators in photovoltaic systems, energy cascade	2
Lec11	Autonomous power supply systems, mobile and stationary	2
Lec12	Solutions, applications and perspective constructions	2
Lec13	Photovoltaic systems; design principles, key components of PV installations	2
Lec14	Photovoltaics in space; high efficiency PV cells	2
Lec15	Exam	2
	Total	**30**

Laboratory		**Number of hours**
La1	Measurement of the light and dark characteristics of PV cells and modules	3
La2	Study of the impact of lighting and temperature on the performance characteristics of PV cells	3
La3	Analysis of the characteristics of PV modules in various configurations	3
La4	Investigation of the spectral distribution of solar radiation and the impact of weather conditions on the efficiency of photovoltaic installations	3
La5	Supplementary classes and crediting	3

La6	Power supply in "zero-energy" systems - testing the properties of power supply and energy storage systems intended for cooperation with miniature photovoltaic cells	3
La7	Power supply in "zero-energy" systems: energy cascade - indirect use of a solar cell in a system with high energy efficiency	3
La8	Small photovoltaic farm - testing the efficiency of a small photovoltaic farm, including series and parallel connection of photovoltaic modules, testing the impact of shading modules	3
La9	Design of an autonomous photovoltaic system using specialized software	3
La10	Supplementary classes and crediting	3
	Total	**30**

TEACHING TOOLS USED
N1. Standard lectures supported with visual presentations and interactive evaluation methods
N2. Midterm evaluation test
N3. Laboratory - short 10 min. written tests at the beginning of exercise
N4. Own work - preparation to practical exercises
N5. Own work - preparation to midterm and final written test
N6. Consultations
N7. Final exam

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Final exam
P2 = F2 (laboratory)	PEU_U01 PEU_K01	Mean results from tests and reports

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. I. Pankove, Zjawiska optyczne w półprzewodnikach, WNT, 1984
[2] Jarzębski, Przetwarzanie energii słonecznej. Konwersja Fotowoltaiczna, WNT, 1981
[3] M. Wacławek, T. Rodziewicz, Ogniwa słoneczne, wpływ środowiska na ich pracę, WNT, 2011

SECONDARY LITERATURE:

[1] Luque, S.Hegedus, Handbook of Photovoltaic Science and Engineering , John Wiley & Sons Ltd., Chichester, England, 2003
[2] J. Poortmans, V. Arkhipov, Thin Film Solar Cells, Fabrication, Characterization and Applications, Wiley Series in Materials for Electronic & Optoelectronic Applications, John Wiley & Sons, 2006
[3] Lasnier, T.G. Ang, Photovoltaic Engineering Handbook, Adam Hilger, 1990
[4] M.A. Green, Third Generation Photovoltaics. Advanced Solar Energy Conversion, in: Springer Series in Photonics , Springer-Verlag, Berlin Heidelberg New York, 2003

[5] M.A.Green , SOLAR CELLS - Operating principles, Technology and System Applications, Univ. of New South Wales, Australia, 1992
[6] P. Wuerfel, Physics of Solar Cells From Priniciples to New Concepts, Wiley-VCH Verkag GmbH &Co. KGaA, 2005
[7] S.R. Wenham, M.A. Green, M.E. Watt, R. Corkish, APPLIED PHOTOVOLTAICS, ARC Centre for Advanced Silicon Photovoltaics and Photonics, Earthscan in the UK and USA, 2007
[8] T. Markvart, Solar Electricity, UNESCO ENERGY ENGINEERING SERIES, John Wiley & Sons, 2000
[9] Zbiory Polskich Norm, PKN

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Microsystem Modeling
Name of subject in English: Microsystem Modeling
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): Electronics, Photonics, Microsystems
Profile: academic
Level and form of studies: 2nd level / full-time studies
Kind of subject: optional / university-wide
Subject code: ETD009575
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	crediting with grade		crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BK) classes	0,6		1,4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge on basics of mathematics and physics
2. Knowledge on basics of computer programming
3. Basic computer skills

SUBJECT OBJECTIVES

C1 Acquainting students with the basics of numerical design of the microelectronic structures
C2 Gaining the knowledge on how to use the numerical modeling software tools based on FEA method
C3 Acquainting students with the typical problems of numerical prototyping as optimization, design of experiments, etc.
C4 Strengthening skills of individual and group work with the available teaching materials
C5 Participation of the students in the carried out research in microsystems modelling

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 Student has basic, structured and theoretically founded knowledge on techniques, methods and engineer numerical tools for MEMS prototyping

Relating to skills:

PEU_U01 Student is able to find right tools for computer aided engineering design, which

could be used in practical applications in the field of numerical prototyping using CAD and FEM software

Relating to social competences:

PEU_K01 Student is able to prioritize appropriately tasks required for implementation of specified problems defined by himself or others

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec1	Modeling of microsystems - Introduction	2
Lec2	Numerical modelling and simulations	2
Lec3	Modeling of mechanical and thermodynamical problems	2
Lec4	Modeling of electromagnetism and fluid dynamics	2
Lec5	Modelling of the coupled fields	2
Lec6	Methods and algorithms for numerical prototyping	2
Lec7	Material engineering in microsystems	2
Lec8	Final test	1
	Total hours	15

Laboratory		**Number of hours**
Lab1	Introduction to modeling using FEM method and FlexPDE software program	2
Lab2	Diffusion equation and analysis in 2D	2
Lab3	Laplace's equation and analysis in 3D	2
Lab4	Analysis of thermal energy transport and temperature distribution	2
Lab5	Analysis of stress and strain state	2
Lab6	Analysis of thermomechanical stress and strain distribution	2
Lab7	Analysis of laminar and turbulent flows	2
Lab8	Analysis of electro-thermo-mechanical problems	2
Lab9	Analysis of electrical capacitance	2
Lab10	Analysis of magnetic field	2
Lab11	Analysis of micromechanical actuator	2
Lab12	Individual project - problem selection and its analysis	2
Lab13	Individual project - discussion, presentation and analysis	2
Lab14	Individual project - assessment	2
Lab15	Additional laboratory term	2
	Total hours	30

TEACHING TOOLS USED
N1. Traditional lecture with multimedia presentations and discussion
N2. Laboratory: 5-minutes introduction and 5-minutes introductory tests
N3. Consultation
N4. Individual work: preparation for lecture
N5. Individual work: preparation for laboratories
N6. Individual work: literature study and preparation for the final test
N7. Individual work: laboratory reports

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01	Discussions and final test
F2 (laboratory)	PEU_U01, PEU_K01	Laboratory tests and quizzes, lab reports
P=F1+F2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] KREYSZIG E., ADVANCED ENGINEERING MATHEMATICS, JOHN WILEY AND SONS,, 2006
[2] Thompson E., Introduction to the Finite Element Method John Wiley and Sons,, 2005
[3] Zienkiewicz O.C., Taylor R.L., The Finite Element Method: Volumes 1-3, Butterworth-Heinemann, London, 2000

SECONDARY LITERATURE:

[1] MONTGOMERY D., DESIGN AND ANALYSIS OF EXPERIMENTS, JOHN WILEY AND SONS, 2005
[2] Montgomery D., Runger G., Applied Statistics and Probability for Engineers, John Wiley and Sons, 2007
[3] William D., Callister Jr., Materials Science and Engineering an Introduction, John Wiley and Sons, 2007

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Analytical Microsystems
Name of subject in English: Analytical Microsystems
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): Electronics, Photonics, Microsystems
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: Optional
Subject code: ETD009576
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	crediting with grade		crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes	0		2		
including number of ECTS points for direct teacher-student contact (BK) classes	0,6		1,4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. No requirements

SUBJECT OBJECTIVES

C1 Gaining knowledge of the operation, production and application of microsystems for chemical and microchemistry
C2 Gaining knowledge of the design and measurement of analytical bio-chips
C3 Participation of the students in the carried out research on analytical microsystems

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 Student has supported by theoretical knowledge of the physico-chemical basis, technology, design, manufacturing, operation and application of analytical microsystems, bio-chips, lab-on-chip and microreactors

Relating to skills:

PEU_U01 Student can describe, evaluate and compare the performance of gas and liquid analytical microsystems; he knows the rules of design, manufacture, operation and the use of microsystems for chemistry and microchemistry

Relating to social competences: PEU_K01 He works independently and in a team

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec1	Introduction. Definition of micro-total-analysis-system (microtas). Systematization, kinds. Position of microtass. Why miniaturization Physic of microtass: flow in microscale: laminar flow vs. vortex flow. Mixing and dozing in micro- and nanovolumes. EHF flow, electroosmotic flow, electro-flow-steerying.	2
Lec2	Technological review: Compatibility of microtass and MEMS. Basic processes. Microtass made of: silicon, silicon and glass, glass, ceramic, plastic, metal. Examples of flow-process-charts. Technological limits.	2
Lec3	Parts of microtass: microvalves - types, realization, parameters, steerying. Capillary channels, nets of channels. Capillary columns for eluation procedures. Vortex and diffusive mixers. Micropums.	2
Lec4	Microdetectors for liquids; conductometric, ion-selective (IGFETs), spectrofluorometric and spectrophotometric with fiber-optics.	2
Lec5	Liquid microtas; CE, FFFE, TFFF, bio-chips, PCR reactors, DNA-chips, immunoassay chips.	2
Lec6	Flow and mass flow gas detectors. Catharometers. Microdosing units. Back-flushed and repetitive real-time dosers.	2
Lec7	Integrated gas chromatographs: construction and steerying. On-line system applications. Microreactors, new chemical apparatus. Market relations, development programmes.	2
Lec8	Final test	
	Total hours	15

Laboratory		**Number of hours**
Lab1	Microvalve and repetitive microinjector: parameters of injection in the computer controlled steerying system with the real-time signals processing	3
Lab2	Gas flow and gas mass flow sensors: flow-through and injection configurations, cooperation to microdosers. Relay time, detection limits, stability, real-time work	3
Lab3	Fluorimetric DNA detection in micro scale	3
Lab4	Micro-fluidic-chip with the open architecture of a fluid maintance, with five microvalves and on-the-chip integrated conductometric sensor. Injection, dozing, mixing in the T, Y configurations. Visualization of data	3
Lab5	Flow and mixing of liquids in micro scale	3
	Total hours	15

TEACHING TOOLS USED
N1. Lecture with presentations and discussion N2. Consultations N3. Short tests at the beginning of exercises, discussions N4. Preparation of the report

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Discussions and final test
P2 = F2 (lab)	PEU_U01, PEU_K01	Laboratory tests and quizzes, lab reports

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Nam-Trung Nguyen, Steven T. Wereley, Fundamentals and applications of Microfluidics, Artech House, 2002

SECONDARY LITERATURE:

[1] Jan A. Dziuban, Technologia i zastosowanie mikromechanicznych struktur krzemowych i krzemowo-szklanych w technice mikrosystemów, Oficyna Wyd. Politechniki Wrocławskiej, 2004

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: MSc Thesis Work
Name of subject in English: MSc Thesis Work
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): Electronics, Photonics, Microsystems
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: optional
Subject code: ETD009581
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					
Number of hours of total student workload (CNPS)					
Form of crediting				crediting with grade	
For group of courses mark final course with (X)					
Number of ECTS points				20	
including number of ECTS points for practical (P) classes				20	
including number of ECTS points for direct teacher-student contact (BK) classes				14	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. ECTS deficit no greater than it is due to the resolution of the Faculty Council.

SUBJECT OBJECTIVES

C1 Conduct by the student thesis on the basis of the acquired while studying structured, underpinned by the theory of general and detailed knowledge with a range of science and technical areas relevant to the field of technical studies.

C2 Writing by a student "thesis" (as work) and to present an oral presentation concerning the issues of the scope of the study Electronicsand Telecommunications, on the basis of the information from the literature and the results of their own work.

C3 Persisting the ability to work independently and in a team.

C4 Participation in research in an area related to the areas of need for relevant to the field of studyof Electronicsand Telecommunications and specialization in Electronics, Photonics, Microsystem.

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 The student executed thesis, based on a knowledge obtained during studying in the field of the Electronics and Telecommunications and specialization in Electronics, Photonics, Microsystems.

Relating to skills:

PEU_U01	Student can create technical texts ("thesis") and multimedia presentations, presenting the results of their research; to obtain and analyze information from the literature, databases, and other proper sources, in the field of the Electronics and Telecommunications and specialization in Electronics, Photonics, Microsystems.

Relating to social competences:

PEU_K01	Student can work independently and interact in a group, taking different roles.

PROGRAM CONTENT		
Project		**Number of hours**
Pr1	Collecting the literature of the subject and to become acquainted with it.	
Pr2	Own work –critical assessment and interpretation of laboratory results.	
Pr3	Writing a thesis as a works.	
Total hours		

TEACHING TOOLS USED
N1. Presentation of selected issues relating to the thesis anddiscussion.
N2. Own work – study of literature from the scope of the topic of the thesis and research work.
N3. Own work – writing technical and scientific text controlled by the promoter
N4. Consultation.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1	PEU_W01	Checking up the thesis realization degree.
F2	PEU_U01	Thesis review.
F3	PEU_K01	Checking up the successive research aims achievement realized personally and in co-operation with research groups.
P = 0,4*F1 + 0,4*F2 + 0,2*F3		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Specialist subject literature agreed with the promoter.

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Ceramic Microsystems
Name of subject in English: Ceramic Microsystems
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): Electronics, Photonics, Microsystems
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: obligatory
Subject code: ETD009582
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	
Number of hours of total student workload (CNPS)	60			60	
Form of crediting	Examination			crediting with grade	
For group of courses mark final course with (X)					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes	0			2	
including number of ECTS points for direct teacher-student contact (BK) classes	1.2			1.4	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Successful completion of the micro-nano technologies
2. Knowledge of basic physics

SUBJECT OBJECTIVES

C1 To familiarize students with the basic phenomena occurring in sensors, transducers and microsystems
C2 Familiarizing yourself with the thick film technology and LTCC (Low Temperature Cofired Ceramics) in the performance of ceramic microsystems
C3 Gaining skills in designing ceramic sensors
C4 Development of ability to work in group
C5 Participation of the students in the carried out research in the field of ceramic microsystems technology

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 Has a structured, theoretically founded knowledge related to the construction, principles of operation, characteristics and application of physical and chemical sensors and microsystems made of thick-film technology and LTCC (Low Temperature Ceramic Cofired); knows the directions of development of LTCC microsystems

Relating to skills:

PEU_U01 Is able to estimate the applicability of the physical and chemical sensors and microsystems manufactured in thick-film and LTCC technology

PEU_U02 Can design selected sensors, actuators and microsystems ceramic. Is able to develop assumptions regarding the structure of selected instruments and to develop the structure of the algorithm technology

Relating to social competences:

PEU_K01 He understands the need for lifelong learning, understand the principle of the sensor elements, which uses and understands the need for sensors to improve human safety, rapid medical diagnostics and environmental control

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec1	General information. Sensors, actuators and microsystems fundamentals and classification. Physical and chemical sensors	2
Lec2	Fundamentals of thick film technology	2
Lec3	Fundamentals of LTCC technology	2
Lec4	Fabrication of passive components with LTCC technology. Mounting of passive components on LTCC substrates. Constrained sintering.	2
Lec5	Microsystem materials and processes characteristic for thick-film and LTCC technologies	2
Lec6	Three dimensional structuration of LTCC substrate	2
Lec7	LTCC bonding with other materials	2
Lec8	Physical sensors. Temperature, radiation and flow sensors - principle of work, construction, properties and application	2
Lec9	Mechanical sensors and actuators. Piezoresistive, magnetoresistive and piezoelectric effects. Pressure, force, displacement sensors	2
Lec10	LTCC – sensors, microsystems. Heating systems. Cooling systems. Fuel cells.	2
Lec11	Foundation of microfluidics	2
Lec12	Microfluidic systems made with LTCC technology. Microvalves/pumps. Micromixers.	2
Lec13	Microfluidic systems made with LTCC technology. Microreactors. Detection modules.	2
Lec14	Generators of cold plasma made with LTCC technology	2
Lec15	Microwave-microfluidic modules made with LTCC technology	2
	Total hours	30

Project		**Number of hours**
Pr 1	Introduction	1
Pr 2	Principles of designing ceramic microsystems	2
Pr 3	Presentation of selected ceramic sensors and microsystems	2
Pr 4	Presentation of selected ceramic sensors and microsystems	2
Pr 5	Design of selected ceramic sensors and microsystems – design of individual layers	2

Pr 6	Design of selected ceramic sensors and microsystems – design of screen	2
Pr 7	Design of selected ceramic sensors and microsystems – design of technological process	2
Pr 8	Project defense	2
	Total hours	15

TEACHING TOOLS USED
N1. Lecture traditional presentations and discussion
N2. Consultation
N3. Self-study and exam preparation
N4. Own work -preparation for the lecture
N5. Own work -preparation for project

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1	PEU_W01 PEU_U01	Discussion, exam
P2 = F2	PEU_U02 PEU_K01	Discussion, reports

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J.W. Gardner, Microsensors, Wiley, 1994
[2] M. Prudenziati, Thick film sensors, Elsevier, 1994
[3] L. Golonka, Zastosowanie ceramiki LTCC w mikroelektronice, Oficyna Wydawnicza Politechniki Wrocławskiej 2001
[4] L. Golonka, K. Malecha, Ceramic microsystems, Printpap, 2011

SECONDARY LITERATURE:

[1] Scientific journals: Sensors and Actuators, Microelectronic Engineering, J. Micromech. Microeng
[2] Conference Proceeding: Conf. Eurosensors, Conf. COE, Conf. IMAPS USA, IMAPS Poland Chapter

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Design and Construction of Optoelectronic Circuits**
Name in English:	**Design and Construction of Optoelectronic Circuits**
Main field of studies:	**Electronics and Telecommunications**
Specialization:	**Electronics, Photonics, Microsystems**
Level and form of studies:	**II level / Full time**
Kind of subject:	**Optional / Faculty**
Subject code:	**ETD009583**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15			15	
Number of hours of total student workload (CNPS)	30			60	
Form of crediting	Z			Z	
Number of ECTS points	1			2	
Including number of ECTS points for practical (P) classes	0			2	
Including number of ECTS points for direct teacher-student contact (BK) classes	0.6			1.4	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic skills and knowledge in electronics

SUBJECT OBJECTIVES

C01 Learn the basics of design of electronic systems with particular emphasis on optoelectronic components
C02 Learn how to perform basic projects optoelectronic circuits, interaction skills and teamwork
C03 The acquisition of skills in software used to design and analysis of electronic circuits
C04 Improving skills in catalogs and electronic databases
C05 Preliminary preparation and participation of the students in conducted scientific research in the field of optoelectronics, particularly on the issue of laser detection systems of silicon microcantilever deflection in near-field microscopy

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 Knowledge and understanding of the areas of application and characteristics of optoelectronic circuits and the basic concepts of design of electronic systems with particular emphasis on optoelectronic components

Relating to skills

PEU_U01 The ability to select technology and data needed to complete project tasks and projects. Individual performing of basic optoelectronic circuits projects

Relating to social competences

PEU_K01 The development of social skills, while also taking responsibility for the results of their actions

PROGRAMME CONTENT

Form of classes - Lecture		Quantity
Le_01	Some organizational lecture: to determine the scope of the course and the requirements for inclusion, discussion of the lecture material, provide a list of literature. Lecture: Principles for determining the technical assumptions and design	2
Le_02	Optoelectronics in electronic circuits. LED types, parameters, and control. Open discussion on the topic	2
Le_03	Semiconductor lasers, types, parameters, and control. Light Detectors - Types, basic configurations preamplifiers. Open discussion on the topic	2
Le_04	Photoelectric Sensors-types, structures, parameters, control. Open discussion on the topic	2
Le_05	Alphanumeric Displays and Imaging. Types, structures, parameters, control, applications. Optocouplers - types, characteristics and applications. Open discussion on the topic	2
Le_06	Light sources and detectors, fiber-optic telecommunications. Light sources and detectors to work with plastic optical fibers. Open discussion on the topic	2
Le_07	Overview of electronic systems of optoelectronic components. Open discussion on the topic	2
Le_08	Summary of the lecture. Prospects for the development of optoelectronic circuit design techniques. Knowledge test	1
	TOTAL	15

Form of classes - Project		Quantity
Pr_01	Determination of the basic assumptions of technical and design for individual student projects. Discuss the practical aspects	2
Pr_02	Analysis of the functions of the designed optoelectronic system. Discuss the practical aspects	2
Pr_03	Analysis of the data directory and the intelligence to adapt to the needs of the project. Discuss the practical aspects	2
Pr_04	Design of optoelectronic circuits meeting technical design assumptions based on existing knowledge and skills. Discuss the practical aspects	2
Pr_05	Design the wiring diagram for the forthcoming project. Simulation of components. Discuss the practical aspects	2
Pr_06	PCB design for the forthcoming project. To visualize the PCBs. Parts distribution inside device housing. The project of the faceplate. Parameters evaluation. Discussion of results	2
Pr_07	Presentation and defense of the projects. Open discussion about them	3
	Total	15

TEACHING TOOLS USED	
ND_01	Traditional lecture with multimedia presentations
ND_02	Presentation of software for the design and analysis of electronic circuits
ND_03	Sample analysis of optoelectronic circuits datasheets
ND_04	Materials for the lecture and project on-line
ND_05	Individual project tasks to execute by each student
ND_06	Common open discussion in the classroom at different stages of learning
ND_07	Consultations and e-mail contact

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Final test
P2 = F2 (project)	PEU_U01, PEU_K01	Rating substantive participation in open discussions in class and rating of the project task design and its presentation

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. J. Siuzdak, Wstęp do współczesnej telekomunikacji światłowodowej, WKŁ, 1999
2. J.E. Midwinter, Y.L. Guo, Optoelektronika i technika światłowodowa, WKŁ , 1995
3. J.Piprek, Optoelectronic Devices, Springer-Verlag, 2005
4. K. Perlicki, Pomiary w optycznych systemach telekomunikacyjnych, WKŁ , 2006
5. K.Booth, Optoelektronika, WKŁ , 2001
6. M. Marciniak, Ł ącznośćświatłowodowa, WKŁ , 1998
7. M. Rusin, Wizyjne przetworniki optoelektroniczne, WKŁ , 2006
8. M. Szustakowski, Elementy techniki światłowodowej?, (Cykl wydawniczy: Fizyka dla przemysłu), WNT, 1992
9. Sz. Szczeniowski, Fizyka doświadczalna, tom IV - Optyka, PWN, 1983

Secondary literature

1. Journals: Elektronika praktyczna, Elektronizacja, Przegląd Telekomunikacyjny itp. and catalogues, 2012
2. A.Bjarklev, S.Benedetto, A.Willner, Optical Fiber Communication Systems, Artech House, London, 1996
3. G.C.Righini, A.Tajani, A.Cutolo, An Introduction to Optoelectronic Sensors, World Scientific Pub (London, Singapore, Taipei), 2009
4. J. Siuzdak, Systemy i Sieci Fotoniczne, WKŁ , 2009
5. M.Karpierz, E.Weinert-Rączka, Nieliniowa optyka światłowodowa, WNT, 2009
6. Noe Reinhold, Essentials of Modern Optical Fiber Communication, Springer-Verlag, 2010
7. Paek Un-Chul, Oh Kyunghwan, Silica Optical Fiber Technology for Device and Components, John Wiley, 2012

SUBJECT SUPERVISOR

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Advanced optoelectronics**
Name in English:	**Advanced optoelectronics**
Main field of studies:	**Electronics and Telecommunications**
Specialization:	**Electronics, Photonics, Microsystems**
Level and form of studies:	**II level / Full time**
Kind of subject:	**Optional / Faculty**
Subject code:	**ETD009584**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15	30	
Number of hours of total student workload (CNPS)	30		30	60	
Form of crediting	Z		Z	Z	
Number of ECTS points	1		1	2	
Including number of ECTS points for practical (P) classes	0		1	2	
Including number of ECTS points for direct teacher-student contact (BK) classes	0.6		0,7	1,4	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of the solid state physics
2. Completed a course of Semiconductor Devices
3. Completed a course of Wave Optics ETD3076
4. Completed a course of Basic of the Solid State Electronics
5. Completed a course of Optoelectronics
6. Completed a course of Semiconductors, Dielectrics and Magnetics
7. Completed a course of Micro- and Nano - Technologies ETD4062

SUBJECT OBJECTIVES

C01 Recollection of the knowledge from the field of optical phenomena existing in semiconductor materials e.g light generation, transmission and absorbance

C02 Presentation of advanced construction of optoelectronic devices including infrared and organic optoelectronic devices. Review of application fields of the discussed optoelectronic devices especially in automotive industry, power industry, microsystems and mechatrionic constructions

C03 Recollection of the knowledge from the field of waveguide constructions including planar optical-fibre. Presentation of the constructions, principle of operation of photonic crystals and applications in the optical devices. Presentation of constructions and principle of operation of advanced optical modulators and switches.

C04	Acquiring of the knowledge from the range of the methods of characterization of semiconductor structures dedicated for constructions of optoelectronics devices. Measurements of optical and electrical parameters of chosen semiconductor structures by using photovoltaic spectroscopy, electrochemical C-V profiling, photoluminescence, photoreflectance and transmission spectroscopy methods.
C05	Practice of the team work skills

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 Expanded and well established knowledge of physics, especially quantum physics and Solid State Physics necessary for understanding physical phenomena affecting the properties of the new materials and advanced photonic devices work

Relating to skills

PEU_U01 Can develop a detailed documentation of the results of experimental work, the research task or design; can prepare an elaboration containing an overview of these results

Relating to social competences

PEU_K01 Can plan and develop a scheme of the realized project, can cooperate and work in a group taking in different roles

PROGRAMME CONTENT

Form of classes - Lecture		Quantity
Le_01	Introduction to optoelectronics: definitions, classifications, applications	1
Le_02	Basic optical phenomena in semiconductors - generation and absorption	1
Le_03	Fundamentals of optoelectronic structure constructions	2
Le_04	Advanced semiconductor light sources.	1
Le_05	Advanced semiconductor photodetectors.	1
Le_06	Optoelectronic systems in automotive industry and mechatronics	1
Le_07	Measurements and analysis of the planar waveguides.	1
Le_08	Fabrication methods of optical layers and planar waveguides.	2
Le_09	Integrated optics devices.	1
Le_10	Basis of nonlinear optics.	1
Le_11	Optical measurement methods.	1
Le_12	Photonic crystals - properties and technology.	1
Le_13	Final test	1
	TOTAL	15

Form of classes - Laboratory		Quantity
La_01	Introduction to the laboratory course - referring of the subjects of the exercises, organization of the semester and rules of evaluation, recollection and discussion of the content of the following exercises, safety instruction.	3
La_02	Measurements of photoluminescence spectra of low dimensional epitaxial structures.	3
La_03	Colorimetric characterization of light sources – RGBW LEDs.	3
La_04	Spatial distribution of light flux and radiometric measurements of light sources.	3
La_05	Design of the quantum structure with required (assumed) electronic structure.	3
	TOTAL	15

Form of classes - Project		Quantity
Cl_01	Introduction to the project - safety instruction, organization of the semester and rules of evaluation	2
Cl_02	Introduction to the software employed during realized classes (Linux, putty, WinSPC, APView)	2
Cl_03	Introduction to the simulation APSYS software	2
Cl_04	Computer simulation of the MSM photodiode	2
Cl_05	Computer simulation of the PIN photodiode	2
Cl_06	Computer simulation of the LED diode	2
Cl_07	Computer simulation and elaboration of reports containing achieved results	18
	Total	30

TEACHING TOOLS USED

ND_01 Traditional lecture with presentations and discussion
ND_02 Consultations
ND_03 Individual work - preparation for a lecture the selected issues
ND_04 Individual work - self-study and preparation for a final test
ND_05 Laboratory: short tests at the beginning of the classes, exercises realized by group
ND_06 Project: Elaboration of the reports with achieved simulation results
ND_07 Individual work - preparation for realized laboratory exercises
ND_08 Individual work - preparation for realized project classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Final test
P2 = F2 (lab)	PEU_U01, PEU_K01	Tests and reports
P3 = F3 (project)	PEU_U01, PEU_K01	Reports

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. B. Mroziewicz, M. Bugajski, Wł. Nakwaski, Lasery półprzewodnikowe, WNT 1985
2. J. E. Midwinder, Y. L. Guo, Optoelektronika i technika światłowodowa, WKŁ 1995
3. J. I. Pankove, Zjawiska optyczne w półprzewodnikach, WNT 1984
4. J. Piotrowski, A. Rogalski, Półprzewodnikowe detektory podczerwieni, WNT 1985
5. B. Ziętek Optoelektronika, Wyd. UMK, 2004
6. Z. Bielecki, A. Rogalski, Detekcja sygnałów optycznych, WNT 2001

Secondary literature

1. A. Smoliński, Optoelektronika światłowodowa, WKŁ 1985
2. J. Hennel, Podstawy elektroniki półprzewodnikowej, WNT 1986
3. J. Godlewski, Generacja i detekcja promieniowania optycznego, PWN 1997
4. J. Siuzdak, Wstęp do współczesnej telekomunikacji światłowodowej, WKŁ 1997
5. M. Marciniak, Łączność światłowodowa. WKŁ 1998
6. G. Einarsson, Podstawy telekomunikacji światłowodowej, WKŁ 1998
7. K. Booth, S. Hill, Optoelektronika, WKŁ, 2001
8. R. Bacewicz, Optyka ciała stałego, Oficyna Wydawnicza Politechniki Warszawskiej, 1995

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Packaging of EPM**
Name in English:	**Packaging of EPM**
Main field of studies:	**Electronics and Telecommunications**
Specialization:	**Electronics, Photonics, Microsystems**
Level and form of studies:	**II level / Full time**
Kind of subject:	**Optional / Faculty**
Subject code:	**ETD009585**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		30		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	Z		Z		
Number of ECTS points	1		2		
Including number of ECTS points for practical (P) classes	0		2		
Including number of ECTS points for direct teacher-student contact (BK) classes	0.6		1.4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

No requirements

SUBJECT OBJECTIVES

C01 Mastery of theoretical knowledge of electronic assembly and packaging
C02 Gaining practical skills through laboratory tasks
C03 Consolidation of skills of group work

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 Has a structured and theoretically founded knowledge in the field of electronic assembly allows independent performance of electronic systems based on the available electronic components and assembly techniques

Relating to skills

PEU_U01 Is able to properly select and apply the techniques of electronic assembly, depending on design requirements and reliability of devices

Relating to social competences	
PEU_K01	Is able to set priorities in the use of adequate techniques for electronic assembly

PROGRAMME CONTENT		
Form of classes - Lecture		Quantity
Le_01	Packaging hierarchy and technologies	1
Le_02	Wire bonding	1
Le_03	Flip Chip technology	2
Le_04	Printed circuit boards	2
Le_05	Passive and active components for packaging	2
Le_06	Fundamentals of soldering process	2
Le_07	Overview of soldering technologies	2
Le_08	Defects of solder joints	2
Le_09	Colloquium	1
	TOTAL	15

Form of classes - Laboratory		Quantity
La_01	Introduction to laboratories	2
La_02	Measurement of surface ionic contaminants on printed circuit boards	4
La_03	Assembly of SMT devices on printed circuit boards	4
La_04	Assessment of solder joints by measuring the shear strength of solder joints	4
La_05	Rework station and manual soldering	4
La_06	Measurement of resistance of electrically conductive adhesives	4
La_07	Combined loading tests of soldered joints reliability	4
La_08	Supplementary term and visiting other lab facilities	4
	Total	30

TEACHING TOOLS USED	
ND_01	Traditional lecture with multimedia presentations and discussion
ND_02	Consultations
ND_03	Self-study and preparation for test
ND_04	A short, 10-minute introduction and assessment of student preparation (at the beginning of the laboratory)
ND_05	A brief summary of the results of the work carried out (at the end of the laboratory)
ND_06	Self-study and preparation for laboratory classes

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Discussions and final test
P2 = F2 (lab)	PEU_U01, PEU_K01	Laboratory tests and quizzes, lab reports

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. Fałat T., Felba J., Matkowski P., Packaging of Electronics, Photonics and Microsystems, PRINTPAP Łódź, 2011
2. Tummala R.R., Fundamentals of Microsystem Packaging, McGraw-Hill, 2001

Secondary literature

1. Felba J., Montaż w elektronice, Oficyna Wydawnicza Politechniki Wrocławskiej, 2010
2. Ganesan S., Pecht M., Led-free Electronics, John Willey & Sons Inc., 2006
3. Harper Ch.A., Electronic Packaging and Interconnection Handbook, McGraw-Hill, 1991
4. Suhir E., Lee Y.C., Wong C.P., Micro- and Opto- Electronic Materials and Structures, Springer S+B Media Inc., 2007

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FACULTY OF MICROSYSTEM ELECTRONICS AND PHOTONICS

SUBJECT CARD

Name of subject in Polish: Diploma Seminar
Name of subject in English: Diploma Seminar
Main field of study (if applicable): Electronics and Telecommunications
Specialization (if applicable): Electronics, Photonics, Microsystems
Profile: academic
Level and form of studies: 2nd level, full-time studies
Kind of subject: optional
Subject code: ETD009586
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					30
Number of hours of total student workload (CNPS)					60
Form of crediting					crediting with grade
For group of courses mark final course with (X)					
Number of ECTS points					2
including number of ECTS points for practical (P) classes					2
including number of ECTS points for direct teacher-student contact (BK) classes					1.4

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Shortage of ECTS points not greater than resulting from resolution of the Faculty Council

SUBJECT OBJECTIVES

C1 Student acquires presentation skills of personal qualifications in the field of knowledge, learning and social competences.
C2 Fixing of skills to work collectively.

SUBJECT LEARNING OUTCOMES

Relating to knowledge:

PEU_W01 The student has well-ordered and theoretically established knowledge in the field that is demanded in Electronics and Telecommunication field of study and Electronics, Photonics and Microsystems specialization.

Relating to skills:

PEU_U01 The student is able to present personal qualifications in the range of knowledge, learning and social competences proper to Electronics and Telecommunication field of study and Electronics, Photonics and Microsystems specialization.

Relating to social competences:

PEU_K01	The student is able to think and act in a creative and enterprising way and to co-operate and work in a group (collectively) accepting various roles in it.

PROGRAM CONTENT		
Seminar		**Number of hours**
Se1	Introduction to the seminar	1
Se2	Thesis, final examination -general information, regular requirements obligatory in Wrocław University of Science and Technology, the rules of technical and scientific texts creation.	2
Se3	Thesis -students discuss the subject matter and scope of expected research.	3
Se4	Multimedia presentation of CV done by every seminar participant.	4
Se5	Discussion of the exam questions.	8
Se6	Thesis – multimedia presentations of received result.	6
Se7	Thesis -short presentation prepared for the final examination.	4
Se8	Summary of the seminar and crediting.	2
Total hours		30

TEACHING TOOLS USED
N1. Presentation of selected issues concerning the thesis and discussion.
N2. Personal work -preparation to multimedia presentation of assigned problems.
N3. Personal work -individual studies and preparation to the final examination.
N4. Consultations.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1	PEU_W01, PEU_U01, PEU_K01	Control of the activity during classes and participation in the discussion.
F2	PEU_U01	Assessment of the presentations about the examination topics.
F3	PEU_U01	Assessment of the presentations about the progresses in the diploma thesis.
P = 0,4*F1 + 0,4*F2 + 0,2*F3		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[1] Regulations governing higher education studies at Wrocław University of Science and Technology.
[2] Notes from lectures.
[3] Scientific publications from the field of the realised diploma thesis.

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**Sensors and actuators**	
Name in English:	**Sensors and actuators**	
Main field of studies:	**Electronics and Telecommunications**	
Level and form of studies:	**II level**	**/ Full time**
Kind of subject:	**Obligatory**	**/ Faculty**
Subject code:	**ETD009588**	
Group of courses:	**NO**	

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15				
Number of hours of total student workload (CNPS)	60				
Form of crediting	Z				
Number of ECTS points	2				
Including number of ECTS points for practical (P) classes	0				
Including number of ECTS points for direct teacher-student contact (BK) classes	1.2				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

No requirements

SUBJECT OBJECTIVES

C01 Organization of knowledge in the fields of micromechanical sensors and actuators
C02 To familiarize oneself with basic properties of micromechanical sensors
C03 To familiarize oneself with methods and algorithms of analog and digital conditioning of signals from micromechanical sensors
C04 Participation of the students in the carried out research on micromechanical sensors and actuators

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 Has knowledge in the field of sensor techniques, knowledge necessary to understand physical and mechanical principles of operation of micromechanical sensors and actuators, knows dependencies between operation parameters and the construction, has knowledge of technology of micromechanical sensors

PROGRAMME CONTENT		
Form of classes - Lecture		Quantity
Le_01	Review of chosen methods of actuation and sensing utilized with MEMS	2
Le_02	Introduction to fundamental mechanics of microstructures, bending, tensing in various micromechanical structures	2
Le_03	Piezoresitive pressure sensor - principle of operation, construction	3
Le_04	Piezoresitive pressure sensor - parameters, conditioning of electric signal, examples of realisations	2
Le_05	Acceleration sensors, gyroscopes - principles of operation, construction, parameters and examples of realisations	2
Le_06	Micromachines	2
Le_07	Final colloquium	2
	TOTAL	15

TEACHING TOOLS USED
ND_01 Lecture with multimedia presentation and discussion ND_02 Self-work - preparation to final colloquium

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Final colloquium

PRIMARY AND SECONDARY LITERATURE
Primary literature
1. M. Bao, Analysis and Design Principles of MEMS Devices, Elsevier, 2005

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Faculty of Microsystem Electronics and Photonics

SUBJECT CARD

Name in Polish:	**MOEMS**
Name in English:	**MOEMS**
Main field of studies:	**Electronics and Telecommunications**
Specialization:	**Electronics, Photonics, Microsystems**
Level and form of studies:	**II level / Full time**
Kind of subject:	**Optional / Faculty**
Subject code:	**ETD009589**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	30		60		
Form of crediting	Z		Z		
Number of ECTS points	1		2		
Including number of ECTS points for practical (P) classes	0		2		
Including number of ECTS points for direct teacher-student contact (BK) classes	0.6		1.4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Fundamentals of the microsystem and microingineering technology, a base knowledge of optoelectronics and optics

SUBJECT OBJECTIVES

C01 Mastering knowledge on the mechanically passive and active optical microsystems
C02 Conducting own experiments with selected MEOMS-s on a laboratory scale
C03 Participation of the students in the research in topics related to MEOMS

SUBJECT LEARNING OUTCOMES

Relating to knowledge

PEU_W01 He has in-depth knowledge of the manufacturing processes of optical microsystems, their design parameters and performance

Relating to skills

PEU_U01 He is able to develop a detailed documentation of the results of the experiment and prepare a report

Relating to social competences

PEU_K01 He is able to interact and work in a group assuming different roles in it

PROGRAMME CONTENT

Form of classes - Lecture		Quantity
Le_01	MEMS and MEOMS technological compatibility, classification of MEOMS, application fields, market, manufacturers, history and future development	2
Le_02	Static microoptical components: couplers, microlenses, diffraction grids 1-D and 2-D, microoptical benches, other constructions	2
Le_03	Movable microoptical components: mirrors, switcher, adaptive optics, DMD projectors, confocal and SNOM microscopes on-chip, opto-mechanical memory	2
Le_04	Light-beam modulators, optical filters, LIGA microspectrometers	2
Le_05	Physical and chemical MOEMS microsensors, microsensors for analytical applications, VIS/NIR spetrophotometric sensors in chemistry, bio and med science	2
Le_06	Spectrofluorometric sensors: scale factor, chromophores, excitation light sources, detectors, application in ELISA/DNA-chip and portable instruments	2
Le_07	CPT effect and its application in integrated cesium clocks, magnetometers and interferometric devices	2
Le_08	Summary and final test	1
	TOTAL	15

Form of classes - Laboratory		Quantity
La_01	Computer aided simulation of the silicon membrane	3
La_02	Optical fiber sensor	3
La_03	VIS spectrometric detector	3
La_04	NIR spectrometric detector	3
La_05	Optical microswitch	3
	Total	15

TEACHING TOOLS USED

ND_01 Lecture with presentations and discussion
ND_02 Short tests at the beginning of exercise
ND_03 Consultations
ND_04 Reports of the laboratory exercises

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 = F1 (lecture)	PEU_W01	Final test
P2 = F2 (lab)	PEU_U01, PEU_K01	Discussions, laboratory tests and quizzes, lab reports

PRIMARY AND SECONDARY LITERATURE

Primary literature

1. P. Rai-Choudhury, MEMS and MOEMS Technology and Applications, SPIE Press

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FACULTY OF MICROSYSTEM ELECTRONIC AND PHOTONICS

SUBJECT CARD

Name of subject in Polish	**MATEMATYKA**
Name of subject in English	**MATHEMATICS**
Main field of study (if applicable)	**Electronics and Telecommunications**
Level and form of studies	**2nd level, full-time studies**
Kind of subject	**obligatory / university-wide**
Subject code	**MAT001449**
Group of courses	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	30			
Number of hours of total student workload (CNPS)	60	60			
Form of crediting	exam	crediting with grade			
For group of courses mark final course with (X)					
Number of ECTS points	2	2			
including number of ECTS points for practical (P) classes		2			
including number of ECTS points for direct teacher-student contact (BK) classes	1,2	1,4			

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of differential and integral calculus of functions of one and several variables.
2. Knowledge of the properties and applications of complex numbers and matrices.
3. Knowledge of the theory and applications of number series and power series.

SUBJECT OBJECTIVES

C1 Exposition of the basic concepts of linear spaces.
C2 Exposition of the basic properties of Fourier series and Fourier transforms.
C3 Exposition of the basic concepts, theorems, methods and applications relating to ordinary differential equations using the equations of the first and second order and linear systems of ordinary differential equations of the first order.
C4 Exposition of the basic concepts, theorems and methods for simple partial differential equations and integral equations of type Volterra and Fredholm.

SUBJECT LEARNING OUTCOMES

Relating to knowledge a student

PEU_W01 has a basic knowledge of linear space.
PEU_W02 has a basic knowledge of Fourier series and Fourier transforms.
PEU_W03 has a basic knowledge of ordinary differential equations with a particular focus on equations of first and second order and linear systems of ordinary differential equations of the first order.
PEU_W04 has a basic knowledge of partial differential equations of first and second order and integral equations of type Volterra and Fredholm.

Relating to social competences a student

PEU_U01 can calculate Fourier series and Fourier transform of basic functions.
PEU_U02 is able to solve the equations of the first order with separated variables, linear, homogenous

and Bernoulli, second-order equations reducible to first order, and the equation with constant coefficients, systems of linear ordinary differential equations of the first order by matrix methods.
PEU_U03 can solve simple partial differential equations and apply iterative methods for solving integral equations of type Volterra and Fredholm.

Z zakresu kompetencji społecznych student
PEU_K01 understands the need for a systematic and independent work on the mastery of course material.

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec1	The finite-dimensional and infinite-dimensional linear spaces. Examples.	2
Lec2	Trigonometric Fourier series.	3
Lec3	Fourier transform and its basic properties. Convolution.	3
Lec4	Ordinary differential equations of the first order. The initial value problem for the first order differential equation. A direction field. Picard's theorem on the existence and uniqueness of solutions of Cauchy initial value problem for the equation of the first order.	2
Lec5	Linear differential equations of the first order. The method of integrating factor. Bernoulli equation. Orthogonal curves.	3
Lec6	Ordinary differential equations of the second order. Initial value problems for ordinary differential equations of second-order. Ordinary differential equations of second order differential equations reducible to first order.	3
Lec7	Ordinary differential equations of second order linear homogeneous and heterogeneous. The method of variation of parameters.	2
Lec8	Homogeneous systems of linear differential equations. The Euler method.	2
Lec9	Partial differential equations of the first order. The integral of linear homogeneous equation. Clairaut equation. Transport equation.	3
Lec10	Partial differential equations of the second order. Wave equation. The heat equation. Laplace equation.	3
Lec11	Integral equations of the first and second kind, Fredholm and Volterra equations. Examples. Abel integral equation. Fredholm equation with degenerate kernel.	4
	Total hours	**30**

Classes		**Number of hours**
Cl1	Analyzing the issues related to the concepts of linear space.	3
Cl2	Determination and study of Fourier series.	3
Cl3	Determination of the Fourier transform and convolution.	2
Cl4	Solving of linear differential equations of the first order of separated variables, homogenous and Bernoulli equations. Application of the above equations.	4
Cl5	Solving differential equations of the second order and their applications.	3
Cl6	Solving systems of linear differential equations.	3
Cl7	Solving partial differential equations of the first order.	3
Cl8	Solving partial differential equations of the second order.	3
Cl9	Solving integral equations of the Volterra and Fredholm kind.	4

Cl10	Test.	2
	Total hours	**30**

TEACHING TOOLS USED
N1 Lecture - traditional method or using multimedia tools.. N2 Classes – traditional method (problems sessions and discussion). N3 Tutorial. N4 Student's own work - preparation for exercises.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation: F – forming (during semester), P – concluding (at semester end)	Evaluation: F – forming (during semester), P – concluding (at semester end)	Evaluation: F – forming (during semester), P – concluding (at semester end)
F(W)	PEU_U01-PEU_U03 PEU_K01	Oral answers, quizzes, tests
F(C)	PEU_W01-PEU_W04	Exam
P=F		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. D. Logan, A first course in differential equations, SpringerVerlag, NY 2006.
[2] M. Gewert i Z. Skoczylas, Równania różniczkowe zwyczajne. Teoria, przykłady, zadania, Oficyna Wydawnicza GiS, Wrocław 2006.
[3] F. Bierski, Funkcje zespolone – Szeregi Fouriera i przekształcenie Fouriera, przekształcenie całkowe Laplace'a, przekształcenie Laurenta, Uczelniane Wydawnictwa Naukowo-Dydaktyczne, Kraków, 1999.
[4] A. Piskorek, Równania całkowe. Elementy teorii i zastosowania, WNT, Warszawa, 1997.

SECONDARY LITERATURE:

[1] P. Blanchard, R. L. Devany, and G. R. Hall, Differential Equations, 3rd ed., Thompson, Brook/Cole, Belmont, CA, 2006.
[2] A. Palczewski, Równania różniczkowe zwyczajne, WNT, Warszawa 2004.
[3] A. N. Tichonow, A. A. Samarski, Równania fizyki matematycznej, PWN, Warszawa 1963.
[4] K. T. Tang, Mathematical Methods for Engineerd and Scientis 2, Springer-Verlag, Berlin Heidelberg, 2007.
[5] K. T. Tang, Mathematical Methods for Engineerd and Scientis 3, Springer-Verlag, Berlin Heidelberg, 2007.

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