,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	