THE MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
LVIV POLYTECHNIC NATIONAL UNIVERSITY

ACCEPT

Rector of
Lviv Polytechnic National University
_____ Yurii Bobalo
26 05 2020

EDUCATIONAL-PROFESSIONAL PROGRAM
"INFORMATION CONTROL SYSTEMS AND TECHNOLOGIES"
THE SECOND (MASTER'S) LEVEL OF HIGHER EDUCATION

BRANCH OF KNOWLEDGE	12 Information Technology
SPECIALTY	122 Computer Science
PROGRAM	Information Control Systems and Technologies
QUALIFICATION	Master of Computer Science with specialization in information control systems and technologies

Considered and approved
by Lviv Polytechnic National University
Scientific Council
"20 05 2020
Protocol No 63

Lviv 2020

LETTER OF AGREEMENT

of educational-professional programs

The level of higher education	The second (master's)
Branch of knowledge	12 Information Technology
Specialty	122 Computer Science
Specialization	Information Control Systems and Technologies
Qualification	Master of Computer Science with specialization in information control systems and technologies

DEVELOPED AND APPROVED

Scientific and Methodical Commission of the specialty 122 "Computer Science"

Protocol No 6

16 04 2020

The Head of the SMC of the specialty

U. Marikutsa

AGREED

The Vice-Rector on scientific and pedagogical work of Lviv Polytechnic National University

O. Davydchak

20 05 2020

Head of educational and methodical Department

V. Sviridov

20 05 2020

RECOMMENDED

The scientific-methodical Council of the University

Protocol No 48

"20 05 2020

The head of the SMC of the University

A. Zagorodniy

Director of Educational-Scientific Institute of Computer Science and Information Technologies

M. Medykovskyy

16 04 2020

PREFACE

Developed by the working group of the Scientific and Methodological Commission of the specialty 122 "Computer Sciences" of the National University "Lviv Polytechnic" in the composition of:

Ivan Tsmots	- Doctor of Sciences, Professor, Head of ACS Department
Mykola Medykovskyy	- Doctor of Sciences, Professor, Director of the Institute
Kvitoslava Obelovska	- PhD, Associate Professor, ACS Department
Yurii Tsymbal	- PhD, Associate Professor, ACS Department

The following persons were involved in the development of the educational-professional program:

Andrii Zelinskyy	– employer's representative
Ivan Boyko	– master's level student

Guarantor of the educational-professional program
"Information Control Systems and Technologies" _____ I. Tsmots

The project of the educational-professional program was discussed and approved at the meeting of the Scientific Council of the Educational-Scientific Institute of Computer Science and Information Technologies.
Protocol No 8-2019/2020 from 12 квітня 2020 р.

Chairman of the Scientific Council _____ M. Medykovskyy

APPROVED AND ENACTED
By order of the Rector of Lviv Polytechnic National University
02 06 2020 262-1-10

1. Profile of the Master's program for the specialty 122 "Computer Science" with a specialization in "Information Control Systems and Technologies"

1 – General information	
The full name of the institution of higher education and the structural unit	**Lviv Polytechnic National University,** Department of Automated Control Systems Institute of Computer Science and Information Technologies
The level of higher education	The second (Master's)
Branch of knowledge	12 Information Technology
Specialty	122 Computer Science
The official name of educational program	Information Control Systems and Technologies
Internet address of the program	https://directory2023.lpnu.ua/majors/ikni/8.122.00.01/19/2022/ua/full
Restrictions on forms of education	Missing
Educational qualification	Master of Computer Science
Qualification in diploma	Level of higher education – Master Specialty – 122 Computer Science Educational program – Information Control Systems and Technologies
The full name of the qualification in the original language	Master of Computer Science with specialization in information control systems and technologies
Description of the subject area	*Object(s) of study and/or activity*: the processes of collecting, presenting, processing, storing, transmitting and accessing information in computer systems. *Learning goals:* to provide in-depth theoretical knowledge and practical skills and abilities sufficient for the successful performance of professional duties in the specialty 122 "Computer Science" with the specialization "Information Control Systems and Technologies" and prepare students for further employment. *Theoretical content of the subject area*: modern models, methods, algorithms, technologies, processes and methods of obtaining, presenting, processing, analyzing, transmitting, storing data in information and computer systems. *Methods, techniques, technologies*: methods and algorithms for solving theoretical and applied problems of computer science; mathematical and computer modeling, modern programming technologies; methods of collection, analysis and consolidation of distributed information; technologies and methods of design, development and quality assurance of information technology components, computer graphics methods and data visualization technologies; knowledge engineering technologies, CASE modeling and IT design technologies. *Tools and equipment*: distributed computing systems; computer networks; mobile and cloud technologies, database management systems, operating systems, means of developing information systems and technologies.

Academic rights of graduates	Obtaining an education according to the educational program of the third (educational-scientific) level of higher education and obtaining additional qualifications in the adult education system.
Employment of graduates	Primary jobs in the fields of research, production, consulting activities in the fields of information technology, communication, and in the management bodies of enterprises and companies: IT companies, financial companies, insurance companies, state institutions, research organizations, information technology consulting, etc. Graduates can work in professions according to the National Classifier of Professions DK 003:2010: 2131.1 Research staff (computer systems). 2131.2 Developers of computing systems. 2132.1 Research staff (programming). 2132.2 Developers of computer programs. 2310.2 Other teachers of higher education institutions. 2321 Teachers of professional (vocational and technical) education institutions. 2322 Teachers of vocational pre-higher education institutions.
The amount of credits under the European Credit Transfer System required to obtain the relevant higher education degree	Based on a Bachelor's degree (level 6 of the NQF) or a higher level of education - 90 ECTS. The minimum volume of ECTS intended for practice is 10 credits. At least 35% of the volume of the educational program is aimed at providing general and special (professional) competencies defined by this standard of higher education.
The availability of accreditation	Accredited by the Ministry of Education and Science of Ukraine
Cycle/level	The NQF of Ukraine – 7 level, FQ-EHEA-second cycle, QF-LLL- 6 level
Prerequisites	The Bachelor's degree
Language (s) of teaching	Ukrainian language
Basic concepts and their definitions	The program uses basic concepts and their definitions in accordance with the Law of Ukraine "On Higher Education", as well as the Standard of Higher Education of Ukraine: second (master's) level, field of knowledge – 12 Information Technologies, specialty – 122 Computer Science
2 – The goal of the educational program	
	To provide students with the acquisition of in-depth theoretical and practical knowledge, skills, and understanding related to the areas of information management systems and technologies and computational intelligence, which will enable them to effectively perform tasks of an innovative nature at the appropriate level of professional activity, which is focused on research and solving complex problems of design and development of information systems to meet the needs of science, business, and enterprises in various fields.
3 – Characteristics of the educational program	
The orientation of the educational program	The educational and professional program is based on the well-known provisions and results of modern scientific research on information control systems and technologies.
The main focus of educational programs and specializations	Research and development of methods and means of intellectualization of informational control systems and technologies.

	Keywords: information control systems and technologies, intelligent data processing, adaptive control systems, neural networks, signal and image processing.
Peculiarities and differences	The program is focused on the assimilation and development of promising areas of information control systems and technologies using modern intellectualization tools, network solutions, and hardware components. In general, there are 2 professional lines: *Elective block 01. Intelligent control systems and technologies.* *Elective block 02. Specialized real-time information technologies.*
4 – Suitability of graduates of the educational program for employment and further education	
Suitability for the employment	Primary jobs in the areas of scientific research, production, consulting activities in the fields of information technology, communication and in the management bodies of enterprises and companies: IT companies, financial companies, insurance companies, state institutions, research organizations, consulting on information technologies, etc.
Further training	The possibility to continue studying in the program of the third level of higher education. All programs of the Doctor of Philosophy (PhD) in the field of knowledge "Information Technologies".
5 – Teaching and evaluation	
Teaching and learning	A combination of lectures, practical classes with solving specific problems in the field of information control systems and technologies, implementation of projects, research laboratory work, consultations with teachers, course works, practices, preparation of a master's thesis.
Evaluation	Exams, oral and written tests, lab reports, defense of course projects (works), essays, presentations, defense of master's thesis.
6 – Program competences	
Integrated competence (INT)	The ability to solve problems of research and/or of an innovative nature in the field of computer sciences.
General competences (GC)	GC01. Ability to abstract thinking, analysis and synthesis. GC02. Ability to apply knowledge in practical situations. GC03. The ability to communicate in the national language both orally and in writing GC04. Ability to communicate in a foreign language. GC05. Ability to learn and master modern knowledge. GC06. The ability to be critical and self-critical. GC07. Ability to generate new ideas (creativity).
Professional competences of the specialty (SC)	SC01. Understanding the theoretical foundations of computer science. SC02. The ability to formalize the subject area of a certain project in the form of an appropriate information model. SC03. Ability to use mathematical methods to analyze formalized models of the subject area. SC04. The ability to collect and analyze data (including large data) to ensure the quality of project decision-making. SC05. Ability to develop, describe, analyze and optimize architectural solutions of information and computer systems for various purposes. SC06. Ability to apply existing and develop new algorithms for solving problems in the field of computer science.

	SC07. Ability to develop software according to formulated requirements, taking into account available resources and constraints. SC08. The ability to develop and implement software creation projects, including in unpredictable conditions, with unclear requirements and the need to apply new strategic approaches, use software tools to organize teamwork on the project. SC09. Ability to develop and administer databases and knowledge bases. SC10. The ability to assess and ensure the quality of IT projects, information and computer systems of various purposes, to apply international standards for assessing the quality of software of information and computer systems, models for assessing the maturity of information and computer systems development processes. SC11. Ability to initiate, plan and implement the development processes of information and computer systems and software, including its development, analysis, testing, system integration, implementation and support. *Peculiarities of the program.* SC12. The ability to apply modern technologies of computational intelligence in the development of information control systems and smart systems for various purposes. SC13. The ability to develop, implement, and support problem-oriented and embedded systems for the implementation of intelligent control technologies and smart technologies. SC14. The ability to develop and implement network projects of information management systems, taking into account the problems of information security and data protection. SC15. The ability to ensure safe working conditions in the process of developing and implementing information management systems, to understand the requirements for civil protection and handling in emergency situations.
Professional competences of the specialization (FCS)	*Line 01. Intelligent control systems and technologies* FCS 1.1. The ability to use theoretical and applied knowledge in the field of computer science and information technologies for the development of intelligent information components and the synthesis of information management systems based on them. FCS 1.2. The ability to develop models of components of information management systems, models of complex systems that will ensure their research and optimization. FCS 1.3. The ability to analyze the current state of use of modern information technologies and information management systems of enterprises and institutions and to choose and justify ways of their effective and optimal development. FCS 1.4. The ability to use and implement new technologies when creating and modernizing information management systems, in particular with the aim of increasing their competitiveness. FCS 1.5. The ability to effectively use tools and technologies of modern management in the management of enterprises and institutions and their functioning. *Line 02. Specialized real-time information technologies* FCS 2.1. The ability to analyze problems and tasks in the field of information management systems and technologies, carry out their

	decomposition, formulate requirements, choose and develop effective methods of solving problems. FCS 2.2. Ability to develop software components of information management systems and technologies using modern tools. FCS 2.3. Ability to create information management systems and technologies taking into account all aspects of the task, including creation, promotion, implementation and improvement. FCS 2.4. The ability to communicate with colleagues from this field about scientific achievements at the specialist level and with colleagues from other fields at the general level, the ability to make oral and written reports, discuss scientific topics in the native language and in English. FCS 2.5. Ability to conclude agreements with partners and ensure their implementation on the basis of existing requirements of international and national contract law.
7 - Program learning outcomes	
	LO1. Student is able to identify customer problems and profile aimed at using this knowledge for creating a mass base of consumers to promote the company/product from early sales to the large-scale business. LO2. Student is able to choose innovative information technologies using computational intelligence, big data analysis, the Internet of Things, information and communication tools for smart systems development. LO3. Student is able to design software and hardware for the synthesis of smart systems on their basis with various functional purposes and specified technical characteristics. LO4. Student is able to develop models of multicriteria optimization problems based on the existing input data for managing and supporting decisions in complex systems. LO5. The student is able to evaluate (quantify, compare and select) optimal solutions from a variety of alternatives for solving control problems and supporting decisions in complex systems. LO6. Student is able to evaluate the basic parameters of problem-oriented and embedded computer systems, compare their architectures, choose the architecture with high efficiency of equipment usage to solve problems in real time. LO7. Student is able to develop specialized components of problem-oriented and embedded real-time computer systems to meet the technical requirements. LO8. Student is able to evaluate, compare, select and implement methods and algorithms for providing quality of services for the transmission of different types of traffic in wired and wireless networks. LO9. Student is able to analyze, compare, select and implement optimal data transport technologies and apply principles, strategies, and procedures of Data Protection for information security in computer networks. LO10. Student is able to choose the methods of computational intelligence for processing different data types (including fuzzy and poorly structured) in mobile technical systems. LO11. Student is able to develop software and hardware tools for intelligent data processing in real time for mobile systems with high technical and economic performance.

	LO12. Student is able to assess the adequacy of the proposed recommendations for the creation and maintenance of safe working and living conditions, ensuring civil protection, and responding to emergencies and eliminating their consequences.
	Line 01. Intelligent control systems and technologies LO13.Student is able to choose the architecture of a complex system based on solving the problems of parametric and structural synthesis using the theory of combinatorial configurations. LO14. Student is able to develop an integrated hierarchical control system using component-oriented technology by comparing and selecting system components based on the analysis of their characteristics and the technical task requirements. LO15. Student is able to design the system components with the given parameters aimed at their further use for the synthesis of the integrated hierarchical control system. LO16. Student is able to choose the structure of the industrial Internet of Things and data exchange protocols based on the input data, evaluating their performance characteristics. LO17. Student is able to develop components of the industrial Internet of Things for the collection, pre-processing and exchange of technical data in the management of technological processes and actuators in the technological process automated control systems. *Line 02. Specialized real-time information technologies* LO18. Student is able to choose the components of the computer vision system and the algorithms for image processing and recognition on the basis of the technical task and the integrated approach, evaluating their software and hardware implementation for synthesis of the technical vision system. LO19. Student is able to design hardware and software components to be used for creating a computer vision system. LO20. Student is able to evaluate the characteristics of software and hardware components of computerized digital signal and image processing systems while selecting the digital processing algorithms and forming structures of hardware with high technical and economic performance for real-time implementation. LO21. Student is able to develop specialized processors for the implementation of basic algorithms and operations of digital signal processing in real time and using them synthesize digital signal and image processing systems. LO22. Student is able to select the optimal model of software reliability in hierarchical branched systems on the basis of the technical task and the main methods of evaluation of quantitative and qualitative indicators of software. LO23. Student is able to produce a model for calculating the main characteristics of the reliability of hierarchical branched systems verifying its adequacy by test.
	LO24. Student is able to select team members and distribute responsibilities among them to synergize group task performance. LO25. Student is able to apply principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.

	LO26. Student is able to speak (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.
8 – Resource support for program implementation	
Specific characteristics of staffing	85% of the teaching staff involved in teaching professionally oriented disciplines in the educational program have scientific degrees and academic titles.
Specific characteristics of technical support and logistics	Use of modern hardware and software: IRP - Intelligent Resource Planning, ERP - Enterprise Resource Planning; MRP - Material Requirements Planning; MES – Manufacturing Execution Systems; DSSP – DataSpace Support Platforms; SCADA – Supervisory Control and Data Acquisition; DCS – Distributed Control System; PLC – Programmable Logic Controller; STM, Arduino, Mitsubishi Electric controllers.
Specific characteristics of the information and methodological support	The use of the virtual learning environment of the National University "Lviv Polytechnic" and author's developments of research and teaching staff.
9 – Academic mobility	
National credit mobility	On the basis of bilateral agreements between Lviv Polytechnic National University and technical universities of Ukraine.
International credit mobility	On the basis of bilateral agreements between the Lviv Polytechnic National University and higher educational institutions of foreign countries.
Foreign applicants for higher education	Training of foreign students is possible in Ukrainian and English.
10 – Forms of attestation of applicants for higher education	
Forms of attestation	Attestation is carried out in the form of a public defense of the qualification work (Master's thesis).
Requirements for qualification work (if available)	The qualification work should involve solving a complex task of a research and/or innovative nature in the field of computer science. The qualification work should not contain academic plagiarism, falsification, fabrication. The qualification work must be posted on the website or in the public repository of the Lviv Polytechnic National University. Publication of qualification works containing information with restricted access should be carried out in accordance with the requirements of the law.

2. Distribution of the content of the educational-professional program by component groups and training cycles

No	Training cycle	The volume of the educational load of the student of higher education (credits / %)		
		Mandatory components	Elective components	Total for the entire period of training
1	2	3	4	5
1.	Cycle of general training	3/3,5	3/3,5	6/7
2.	Cycle of professional training	62/68,5	22/24,5	84/93
Total for the entire period of training		**65/72,0**	**25/28,0**	**90/100**

3. List of components of educational-professional program

Code	Components of the educational program	Number of credits	Form of final control
1	2	3	4
Mandatory components (MC)			
1. Cycle of general training			
MC1.1.	Information Marketing and Management	3	exam
Total for the cycle:		**3**	
2. Cycle of professional training			
MC2.1.	Innovative Information Technologies	7	exam
MC2.2.	Next Generation Networks and Data Protection	5	exam
MC2.3.	Problem-oriented and Embedded Computer Systems	5	exam
MC2.4.	Professional and Civil Security	3	test
MC2.5.	Control and Decision Support in Complex Systems	5	test
MC2.6.	Computational Intelligence Technologies	5	exam
MC2.7.	Innovative Information Technologies (course work)	2	test
MC2.8.	Internship on Master Thesis	9	test
MC2.9.	Preparation of Master Thesis	16,5	
MC2.10.	Defense of Master Thesis	4,5	
Total for the cycle:		**62**	
Total for mandatory components:		**65**	
Elective components (EC)			
1. Cycle of general training			
	Elective component 1	3	test
	Total for cycle:	**3**	
2. Cycle of professional training			
Elective groups of components			
Elective components for line 01: Intelligent control systems and technologies			
EC2.1.	Integrated Hierarchical Control Systems	5	exam
EC2.2.	Mathematical Models for System's Synthesis and Optimization	5	test
EC2.3.	Industrial Internet of Things	5	exam
EC2.4.	Integrated Hierarchical Control Systems (course work)	2	test
Total for line 01:		**17**	
Elective components for line 02: Specialized real-time information technologies			
EC3.1.	Computerized Systems of Digital Signal and Image Processing	5	test
EC3.2.	Reliability of Systems and Software	5	test
EC3.3.	Computer Vision Systems	5	exam
EC3.4.	Computer Vision Systems (course work)	2	test
Total for line 02:		**17**	
Elective components of the other educational programs			
	Elective component	5	test
Total for elective components		**25**	
Total for educational-professional program		**90**	

4. Structure, content and consistency between Learning Outcomes, Teaching Methods, and Assessment for Mandatory/Elective Courses of the Study Programme "Information Control Systems and Technologies"

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
MC1. Information Marketing and Management	LO1. Student is able **to identify** customer problems and profile aimed at using this knowledge for creating a mass base of consumers to promote the company/product from early sales to the large-scale business.	**Problem-based learning.** Students (as individuals or in groups) apply course knowledge to produce solutions on resource management and/or product marketing.	Students prepare a written report with recommendations for company management and product marketing strategy.
	LO24. Student is able **to select** team members and distribute responsibilities among them to synergize group task performance.	**Role plays:** Students acting out instructor-assigned roles team members, improvising the script of teamwork, in a realistic and problematic social or interpersonal situation.	Students create teams and distribute responsibilities for obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
MC2. Innovative Information Technology	LO2. Student is able **to choose** innovative information technologies using computational intelligence, big data analysis, the Internet of Things, information and communication tools for smart systems development.	**Problem-based learning.** Students (as individuals or in groups) conduct the research of available methods and technologies making the reasonable choice for real smart system development.	Students prepare a written report on methods and technologies review and make oral presentation on the obtained results substantiating their choice for real smart system.
	LO3. Student is able **to design** software and hardware for the synthesis of smart systems on their basis with various functional purposes and specified technical characteristics.	**Problem-based learning.** Students (as individuals or in groups) apply the course knowledge to design software and hardware components of smart system.	Students prepare a written report on individual task of smart system components development and make oral presentation on the obtained results.
	LO24. Student is able **to select** team members and distribute responsibilities among them to synergize group task performance.	**Role plays:** Students act out instructor-assigned roles team members, improvising the script of teamwork, in a realistic and problematic social or interpersonal situation.	Students create teams and distribute responsibilities for obtained results.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
MC3. Control and Decision Support in Complex Systems	LO4. Student is able **to develop** models of multicriteria optimization problems based on the existing input data for managing and supporting decisions in complex systems.	**Problem-based learning.** Students (as individuals or in groups) apply course knowledge to produce mathematical model for managing and supporting decisions in complex systems.	Students prepare a written report on practical task solving.
	LO5. The student is able **to evaluate** (quantify, compare and select) optimal solutions from a variety of alternatives for solving control problems and supporting decisions in complex systems.	**Problem-based learning:** Students (as individuals or in groups) conduct outside research of a variety of alternatives for solving control problems and supporting decisions in complex systems.	Students prepare a written report on practical task, oral presentation on results of control work.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
MC4. Problem-oriented and Embedded Computer Systems	LO6. Student is able **to evaluate** the basic parameters of problem-oriented and embedded computer systems, compare their architectures, choose the architecture with high efficiency of equipment usage to solve problems in real time.	**Problem-based learning.** Students (as individuals or in groups) apply course knowledge to compare and select problem-oriented and embedded computer systems architectures for real-time problem solving.	Students prepare a written report on practical task solving.
	LO7. Student is able **to develop** specialized components of problem-oriented and embedded real-time computer systems to meet the technical requirements.	**Project-based learning:** Students (as individuals or in groups) apply course knowledge to analyze and to produce the components of problem-oriented and embedded real-time computer systems with given parameters.	Students prepare a written report on practical task, oral presentation on results of control work.

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
MC5. Next Generation Networks and Data Protection	LO8. Student is able **to evaluate**, compare, select and implement methods and algorithms for providing quality of services for the transmission of different types of traffic in wired and wireless networks.	**Problem-based learning.** Students (individually or in groups) apply the knowledge of the course to prepare outside research of a variety of alternatives for solving the next generation network particular problem.	Students prepare an individual written report on a particular topic related to current issues of the next generation networks.
	LO9. Student is able **to analyze**, compare, select and implement optimal data transport technologies and apply principles, strategies, and procedures of Data Protection for information security in computer networks.	**Project-based learning.** Students in groups apply principles, strategies, and procedures of NGN and GDPR for critical thinking to solve non-trivial practical problems to solve particular problems of NGN optimization and realize DPIA (Data Protection Impact Assessment) for some companies or organizations (study case).	Students fill in a written report based on the standard template of DPIA where they make an assessment of the situation with data protection in the company, estimate risks, and make some conclusions and recommendations. The group makes the presentation of the results of DPIA to the instructor.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
MC6. Computational Intelligence Technologies	LO10. Student is able **to choose** the methods of computational intelligence for processing different data types (including fuzzy and poorly structured) in mobile technical systems.	**Problem-based learning.** Students (as individuals or in groups) conduct outside research to select the methods of computational intelligence for processing different data types in a given/developed mobile system.	Students prepare a written report on the obtained results substantiating the choice of computational intelligence methods for data processing in a given/developed technical system.
	LO11. Student is able **to develop** software and hardware tools for intelligent data processing in real time for mobile systems with high technical and economic performance.	**Problem-based learning:** Students (as individuals or in groups) apply course knowledge of intelligent data processing for the development or improvement of the components of real mobile system.	Students prepare a written report on individual task of the development or improvement of the components of real mobile system, make oral presentation on the obtained results.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
MC7. Professional and Civil Security	LO12. Student is able **to assess** the adequacy of the proposed recommendations for the creation and maintenance of safe working and living conditions, ensuring civil protection, and responding to emergencies and eliminating their consequences.	**Inquiry-based learning:** Students learning or applying material for the creation and maintenance of safe working and living conditions in order to answer a question, conduct an experiment, or interpret data.	Students prepare a written report on creating and maintaining safe working and living conditions.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
EC11. Mathematical Models for System's Synthesis and Optimization	LO13.Student is able **to choose** the architecture of a complex system based on solving the problems of parametric and structural synthesis using the theory of combinatorial configurations.	**Problem-based learning.** Students (as individuals or in groups) apply course knowledge to produce mathematical model for optimization of complex systems using combinatorial configurations .	Students prepare a written report on practical task solving.

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
EC12. Integrated Hierarchical Control Systems	LO14. Student is able **to develop** an integrated hierarchical control system using component-oriented technology by comparing and selecting system components based on the analysis of their characteristics and the technical task requirements.	**Problem-based learning.** Students (as individuals or in groups) apply knowledge of basic architectures and understanding of decision-making procedures to develop integrated control systems with complex hierarchic structures.	Students prepare a written report on practical task solving.
	LO15. Student is able **to design** the system components with the given parameters aimed at their further use for the synthesis of the integrated hierarchical control system.	**Project-based learning.** Students as individuals demonstrate theoretical knowledge and practical skills in information control systems and technologies to design components of integrated hierarchical control systems and embedded real-time systems.	Students prepare a written report on practical task, oral presentation on results of control work.
	LO24. Student is able **to select** team members and distribute responsibilities among them to synergize group task performance.	**Role plays:** Students act out instructor-assigned roles team members, improvising the script of teamwork, in a realistic and problematic social or interpersonal situation.	Students create teams and distribute responsibilities for obtained results.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	**Project-based learning.** Students as individuals apply principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
EC13. Industrial Internet of Things	LO16. Student is able **to choose** the structure of the industrial Internet of Things and data exchange protocols based on the input data, evaluating their performance characteristics.	**Problem-based learning.** Students (as individuals or in groups) apply course knowledge to make a substantiated choice of IoT structure and data exchange protocol, to present results, to formulate scientific conclusions, to discuss the conducted research.	Students prepare a written report on practical task, oral presentation on the results obtained.
	LO17. Student is able **to develop** components of the industrial Internet of Things for the collection, pre-processing and exchange of technical data in the management of technological processes and actuators in the technological process automated control systems.	**Project-based learning.** Students as individuals work on practical tasks of IoT components development, present results and discuss them with others.	Students prepare a written report on practical task, oral presentation on results of control work.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals apply principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
EC14. Computer Vision Systems	LO18. Student is able **to choose** the components of the computer vision system and the algorithms for image processing and recognition on the basis of the technical task and the integrated approach, evaluating their software and hardware implementation for synthesis of the technical vision system.	**Project-based learning:** Students (as individuals or in groups) conducting outside research of a variety of components and algorithms for creating computer vision system.	Students prepare a written report on the parts of project.
	LO19. Student is able **to design** hardware and software components to be used for creating a computer vision system.	**Project-based learning.** Students (as individuals or in groups) applying course knowledge to design components of computer vision systems.	Students prepare a written report and oral presentation on the parts of project.
	LO24. Student is able **to select** team members and distribute responsibilities among them to synergize group task performance.	**Role plays:** Students act out instructor-assigned roles team members, improvising the script of teamwork, in a realistic and problematic social or interpersonal situation.	Students create teams and distribute responsibilities for obtained results.

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	**Project-based learning.** Students as individuals apply principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.
EC15. Computerized Systems of Digital Signal and Image Processing	LO20. Student is able **to evaluate** the characteristics of software and hardware components of computerized digital signal and image processing systems while selecting the digital processing algorithms and forming structures of hardware with high technical and economic performance for real-time implementation.	**Problem-based learning.** Students (as individuals or in groups) conduct outside research of a variety of alternatives to select the digital processing algorithm and to form the structures of digital signal processing tools evaluating their parameters.	Students prepare a written report on practical task solving.
	LO21. Student is able **to develop** specialized processors for the implementation of basic algorithms and operations of digital signal processing in real time and using them synthesize digital signal and image processing systems.	**Problem-based learning.** Students (as individuals or in groups) apply knowledge to develop specialized processors and synthesize digital signal and image processing systems.	Students prepare a written report on practical task, oral presentation on results of control work.
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals apply principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.

Mandatory/Elective Courses	Learning Outcomes	Teaching Methods	Assessment
EC16. Reliability of Systems and Software	LO22. Student is able **to select** the optimal model of software reliability in hierarchical branched systems on the basis of the technical task and the main methods of evaluation of quantitative and qualitative indicators of software.	**Problem-based learning:** Students (as individuals or in groups) conduct outside research of a variety of models for assessing software reliability, analyze their characteristics and propose a model suitable for a given system.	Students prepare a written report on individual task solving, make oral presentations and have an interview with the instructor.
	LO23. Student is able **to produce** a model for calculating the main characteristics of the reliability of hierarchical branched systems verifying its adequacy by test.	**Problem-based learning.** Students (as individuals or in groups) apply course knowledge to produce a model for calculating the software reliability characteristics and to perform its testing.	Students prepare a written report and make oral presentations on obtained results
	LO25. Student is able **to apply** principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed independent decisions.	**Project-based learning.** Students as individuals applying principles, strategies, and procedures for critical thinking to solve non-trivial practical problems to make informed, independent decisions.	Students have an individual interview with an instructor on obtained results.
	LO26. Student is able **to speak** (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	**Project-based learning.** Students as individuals speaking (Ukrainian, English) at a high level by using professional terminology and understanding the context to quickly, unambiguously, and concisely express an opinion.	Students make oral presentations on obtained results.

Correspondence of Learning Outcomes with Mandatory/Elective Courses for ICST educational-professional program

	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9	MC10	EC11	EC12	EC13	EC14	EC15	EC16
LO1	+							+	+	+						
LO2		+						+	+	+						
LO3		+						+	+	+						
LO4			+					+	+	+						
LO5			+					+	+	+						
LO6				+				+	+	+						
LO7				+				+	+	+						
LO8					+			+	+	+						
LO9					+			+	+	+						
LO10						+		+	+	+						
LO11						+		+	+	+						
LO12							+	+	+	+						
LO13								+	+	+	+					
LO14								+	+	+		+				
LO15								+	+	+		+				
LO16								+	+	+			+			
LO17								+	+	+			+			
LO18								+	+	+				+		
LO19								+	+	+				+		
LO20								+	+	+					+	
LO21								+	+	+					+	
LO22								+	+	+						+
LO23								+	+	+						+
LO24	+	+						+				+		+		
LO25		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
LO26	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+

Correspondence of Learning Outcomes with Dublin Descriptors for ICST educational-professional program

Dublin Descriptors	Outcome	LO
Knowledge and understanding	demonstration	LO01, LO06, LO08, LO10, LO12, LO13, LO16, LO20
Applying knowledge and understanding	problem solving abilities	LO02, LO03, LO04, LO07, LO11, LO14, LO15, LO19, LO21, LO23
Making judgments	ability to integrate knowledge and handle complexity, formulate judgment with incomplete and limited information	LO05, LO18, LO22, LO25
Communication	communicate conclusions to specialist and non-specialist	LO24, LO26
Learning skills	continue the study	LO9, LO17

The typical jobs for graduates are the following.

Job	The main Education components responsible for knowledge and skills developments
▪ Project Manager	Information Marketing and Management Innovative Information Technology Occupational and Civil Safety
▪ Software Architect	Information Marketing and Management Innovative Information Technology Control and Decision Support in Complex Systems Mathematical Models for System's Synthesis and Optimization Integrated Hierarchical Control Systems Industrial Internet of Things Reliability of Systems and Software
▪ Software Engineer	Innovative Information Technology Problem-oriented and Embedded Computer Systems Next Generation Networks and Data Protection Industrial Internet of Things Reliability of Systems and Software
▪ Embedded Software Engineer	Problem-oriented and Embedded Computer Systems Next Generation Networks and Data Protection Industrial Internet of Things Computer Vision Systems Computerized Systems of Digital Signal and Image Processing
▪ DevOps Engineer	Problem-oriented and Embedded Computer Systems Next Generation Networks and Data Protection Reliability of Systems and Software
▪ Business Analyst	Information Marketing and Management Innovative Information Technology Control and Decision Support in Complex Systems Mathematical Models for System's Synthesis and Optimization Integrated Hierarchical Control Systems
▪ Data Scientist	Control and Decision Support in Complex Systems Computational Intelligence Technologies Mathematical Models for System's Synthesis and Optimization Computer Vision Systems Computerized Systems of Digital Signal and Image Processing
▪ Data Engineer ▪ Big Data Engineer	Computational Intelligence Technologies Innovative Information Technology
▪ Hardware Engineer	Problem-oriented and Embedded Computer Systems Industrial Internet of Things
▪ Quality Assurance Engineer	Reliability of Systems and Software
▪ Cyber Security Engineer	Next Generation Networks and Data Protection
▪ Account (Sales) Manager ▪ Engagement Manager	Information Marketing and Management
▪ HR Manager	Information Marketing and Management Occupational and Civil Safety