

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

«APPROVED»



Rector of  
Lviv Polytechnic  
National University

Yu. BOBALO

“ 29 ” 12 2023 p.

EDUCATIONAL AND PROFESSIONAL PROGRAM  
«SYSTEMS ENGINEERING (INTERNET OF THINGS)»

LEVEL OF HIGHER EDUCATION

The first (bachelor's) level  
(name of the level of higher education)

DEGREE OF HIGHER EDUCATION

Bachelor  
(name of higher education degree)

FIELD OF KNOWLEDGE

12 Information Technology  
(code and name of the field of knowledge)

SPECIALTY

122 Computer Science  
(code and name of specialty)

Reviewed and approved at  
the meeting of the Academic Council  
of the Lviv Polytechnic  
National University  
« 28 » 12 2023.

Protocol No. 7

**LETTER OF AGREEMENT**  
**educational and professional program**

Level of higher education	The first (bachelor's) level
Higher education degree	Bachelor
Field of knowledge	12 Information Technology
Specialty	122 Computer Science
Educational qualification	Bachelor of Computer Science


**DEVELOPED AND APPROVED**

Scientific and Methodical Commission of the  
specialty 122 Computer Science

Protocol No. 4-23/24

“ 16 ” 11 2023.

The Head of the SMC

 Uliana. MARIKUTSA

**AGREED**

The Vice-Rector for Graduate Education of  
Lviv Polytechnic National University

 Oleh DAVYDCHAK

“ 22 ” 12 2023.

Head of Educational and Methodical Department of Lviv Polytechnic National University

 Vasył TOMIUK

“ 22 ” 12 2023.

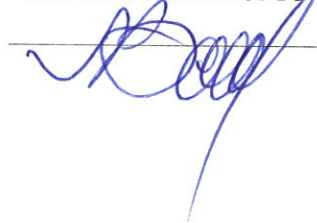
**RECOMMENDED**

By the Scientific and Methodical Council of the  
University

Protocol No. 75

“ 21 ” 12 2023.

The Head of the SMC

 Anatoly ZAHORODNYI

Director of the Educational and Scientific Institute of Computer Technologies, Automation and Metrology

 Mykola MYKYICHUK

“ 19 ” 12 2023.

## PREFACE

Developed in accordance with the Standard of Higher Education of Ukraine of the first (bachelor's) level, field of knowledge 12 Information Technology, specialty 122 Computer Science, approved and put into effect by order of the Ministry of Education and Science of Ukraine No. 962 dated July 10, 2019.

Developed by the working group of the Scientific and Methodical Commission of the specialty 122 Computer Science of the Lviv Polytechnic National University consisting of:

Adrian NAKONECHNYI	– Guarantor of the educational and professional program, Doctor of Sciences, Full Professor, Head of the Department of CAS
VolodymyrSAMOTYI	– Doctor of Sciences, Full Professor, Professor of the Department of CAS
Roman STAKHIV	– PhD, Assoc. Prof., Assistant Professor of the Dept. of CAS
HalynaVLAKH-VYHRYNOVSKA	– PhD, Assoc. Prof., Assistant Professor of the Dept. of CAS
UlyanaDZELENDZYAK	– PhD, Assoc. Prof., Assistant Professor of the Dept. of CAS
AndriyPAVELCHAK	– PhD, Assoc. Prof., Assistant Professor of the Dept. of CAS
Ilona LAHUN	– PhD, Senior lecturer of the Dept. of CAS
ZenoviyVERES	– PhD, Assistant of the Dept. of CAS, Senior Solution Architect at SoftServe
OlehIVANIUK	– PhD, Assoc. Prof., Assistant Professor of the Dept. of CAS, Mentor at SoftServe Academy

With the participation of:

StepanVESELOVSKYI – Executive director of Lviv IT Cluster  
OrestVOVCHAK – Senior Solution Architect at SoftServe.  
RomanPAVLYUK – Vice President, Digital Strategy at Intellias.  
VolodymyrFEDAK – PhD, Engineering Director at SoftServe.

Guarantor of educational program  Adrian NAKONECHNYI

The draft educational and professional program was discussed and approved at a meeting of the Academic Council of the Educational and Scientific Institute of Computer Technologies, Automation and Metrology

Protocol No. 3 from « 21 » 11 2023.

Head of the ICTA Scientific Council  MykolaMYKYICHUK

The draft educational and professional program was discussed and approved at the meeting of the SMC of the Educational and Scientific Institute of Computer Technologies, Automation and Metrology

Protocol No. 2 from « 21 » 11 2023.

Head of the SMC of ICTA  Roman BAYTSAR

APPROVED AND ENFORCED

by order of the Rector of the Lviv Polytechnic National University

from « 29 » 12 2023 No. 676-1-10.

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**1. Profile of the Bachelor's Program in the specialty  
122 "Computer Science"**

<b>1 – General information</b>	
<b>Full name of the Higher education institution and structural unit</b>	Lviv Polytechnic National University, Department of Computerized Automatic Systems, Institute of Computer Technologies, Automation and Metrology
<b>Level of higher education</b>	First (bachelor's) level
<b>Higher education degree</b>	Bachelor
<b>Field of knowledge</b>	12 Information technology
<b>Specialty</b>	122 Computer Science
<b>Name of educational program</b>	Systems Engineering (Internet of Things)
<b>Restrictions on forms of education</b>	Full-time
<b>Educational qualification</b>	Bachelor of Computer Science
<b>Qualification as per degree certificate</b>	Degree of Higher education – Bachelor Specialty – 122 Computer Science Educational program – Systems Engineering (Internet of Things)
<b>Description of the subject area</b>	<p><b>Objects:</b></p> <ul style="list-style-type: none"> <li>– mathematical, informational, simulation models of real phenomena, objects, systems and processes, subject areas, data and knowledge representation</li> <li>– methods and technologies for acquisition, storing, processing, transmitting and using information, intelligent data analysis and decision-making</li> <li>– theory, analysis, development, performance evaluation, algorithm implementation, high-performance computing, including parallel computing and big data.</li> </ul> <p><b>Learning objectives:</b> training specialists capable of conducting theoretical and experimental research in the field of computer science; applying mathematical methods and algorithmic principles in modeling, design, development and support of information technologies; development, implementation and maintenance intelligent systems for analyzing and processing data for organizational, technical, natural and socio-economic systems.</p> <p><b>Theoretical content of the subject area:</b> modern models, methods, algorithms, technologies, processes and methods of obtaining, presenting, processing, analyzing, transmitting, and storing information systems data.</p> <p><b>Methods, techniques and technologies:</b> mathematical models, methods and algorithms for solving theoretical and applied problems that arise in IT development; modern technologies and programming platforms; methods for collecting, analyzing and consolidating distributed information; technologies and methods for designing, developing and ensuring the quality of IT components; computer graphics methods and data visualization technologies; knowledge engineering technologies, CASE-technologies for IT modeling and design.</p> <p><b>Tools and equipment:</b> distributed computing systems; computer networks; mobile and cloud technologies, database management systems, operating systems.</p>
<b>Academic and professional rights of graduates</b>	Entitled to continue their studies at the second (master's) higher education level. Acquisition of additional qualifications in the postgraduate education

ates	system.
<b>The amount of credits under the European Credit Transfer System required to obtain a relevant higher education degree</b>	<p>- based on complete general secondary education - 240 ECTS credits, the duration of study is 3 years and 10 months;</p> <p>- on the basis of the "junior bachelor" degree (the "junior specialist" educational qualification level) is 180 ECTS credits, the duration of study is 3 years.</p> <p>At least 50% of the educational program aimed at providing general and special (professional) competencies in the specialty defined by this higher education standard.</p>
<b>Cycle/level</b>	NQF of Ukraine – level 6, QF-EHEA – first cycle, EQF-LLL – level 6
<b>Prerequisites</b>	Completed secondary education
<b>Language(s) of teaching</b>	Ukrainian language
<b>Basic concepts and their definitions</b>	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: first (bachelor's) level, field of knowledge - 12 Information Technologies, specialty - 122 Computer Science.
<b>2 – The purpose of the educational program</b>	
	To provide students with the knowledge, skills and abilities necessary for comprehensive analysis, forecasting, design and decision-making in complex IoT systems using advanced information technologies, solving problems in various fields of science and technology, finance, socio-economic and political spheres, and the national economy for further study in the chosen educational program.
<b>3 - Characteristics of the educational program</b>	
<b>Orientation of the educational program</b>	<p>An educational and professional program based on well-known and specialized knowledge, the results of modern scientific research in the fields of information technology, computer science, computer engineering, automation and computer-integrated technologies and programming, and focuses on a relevant specialization within which a further professional and scientific career is possible - systems engineering (Internet of Things).</p> <p>The program focuses on the development of Internet of Things devices, equipping household items with embedded computers and sensors, control systems for moving objects, technological process nodes, processing information coming from the environment by its exchange, accumulation and analysis to implement "smart city" and "smart home" and "smart car" systems. The research line is professionally oriented, the expert line is practically oriented.</p>
<b>Main focus of the educational program and specialization</b>	<p>General higher education of the first (bachelor's) level in the field of 12 Information Technology with a specialty of 122 Computer Science.</p> <p>Keywords: systems approach, theory of algorithms, software development, microcontrollers, cloud technologies, databases and knowledge bases, Internet of Things, web technologies, artificial intelligence.</p>
<b>Features and differences</b>	<p>Thorough study and knowledge of the basics of the architecture of IoT systems, development of individual hardware and software modules for such systems, and digital signal processing. Ability to plan experiments to acquire new knowledge.</p> <p>Development of promising directions and approaches to the development of IoT systems for various objects of physical nature.</p> <p>The educational program includes two specialization tracks:</p> <p><b>Track 1. Industrial Internet of Things</b></p> <p>The program develops promising areas for the implementation of information technologies in industry, with a specific emphasis on modern technologies of the Industrial Internet of Things (IIoT).</p> <p><b>Track 2. Internet of Things in Transportation.</b></p>



	The program develops promising areas for the implementation of information technologies in the field of monitoring and management of moving objects in transportation, with a special emphasis on modern achievements in the Internet of Things (IoT).
<b>4 – Eligibility of the educational program graduates for employment and further education</b>	
<b>Eligibility for employment</b>	<p>Professional activity as a specialist in the field of information technology and Internet of Things: IT companies, specialists in the hardware and software development for IoT devices and systems, in the field of information technology and artificial intelligence.</p> <p>Names of professions according to the National Classifier of Ukraine: Classifier of professions):</p> <p>Graduates can work in professions according to the National Classifier of Professions DK 003:2010: (as amended by Order No. 6312 of the Ministry of Economy of Ukraine dated June 23, 2023:</p> <p>213 Computing professionals</p> <p>2131 Computer systems professionals</p> <p>2131.2 Computer systems developers</p> <p>2132 Programming professionals</p> <p>2132.2 Computer software developers</p> <p>2139 Professionals in other areas of computing (computerization)</p>
<b>Further education</b>	The possibility of studying at the second (master's) level of higher education. Obtaining additional qualifications in the postgraduate education system.
<b>5 – Teaching and assessment</b>	
<b>Teaching and learning</b>	A combination of lectures, laboratory and practical classes, completion of coursework and projects, research laboratory work, independent work based on textbooks, study guides and lecture notes, consultations with teachers and IT specialists, internships with IT companies, preparation of a bachelor's qualification thesis.
<b>Evaluation</b>	Written and oral exams, laboratory reports, oral presentations, current control, defense of bachelor thesis.
<b>6 – Program competences</b>	
<b>Integral competence (INT)</b>	The ability of solving complex specialized tasks and practical problems in the field of computer science or in the learning process, which involves the application of theories and methods of information technology and is characterized by the complexity and uncertainty of conditions.
<b>General competencies (GC)</b>	<p>GC1. Ability for abstract thinking, analysis and synthesis.</p> <p>GC2. Ability to apply knowledge in practical situations.</p> <p>GC3. Knowledge and understanding of the subject area and understanding of professional activity.</p> <p>GC4. Ability to communicate in the national language both orally and in writing.</p> <p>GC5. Ability to communicate in a foreign language.</p> <p>GC6. Ability to learn and master modern knowledge.</p> <p>GC7. Ability to search, process and analyze information from various sources.</p> <p>GC8. Ability to generate new ideas (creativity).</p> <p>GC9. Ability for a team work.</p> <p>GC10. Ability to be critical and self-critic.</p> <p>GC11. Ability to make grounded decisions.</p> <p>GC12. Ability to evaluate and ensure the quality of work performed.</p> <p>GC13. Ability to act based on ethical considerations.</p> <p>GC14. Ability to exercise one's rights and responsibilities as a member of society, to realize the values of a civil (free democratic) society and the</p>

	<p>need for its sustainable development, the rule of law, and the rights and freedoms of man and citizen in Ukraine.</p> <p>GC15. Ability to preserve and multiply the moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and engineering, to use various types and forms of physical activity for active recreation and leading a healthy lifestyle.</p> <p>GC16. Ability to make decisions and act in accordance with the principle of inadmissibility of corruption and any other manifestations of dishonesty.</p>
<b>Special (professional, subject) competencies of the specialty (SC)</b>	<p>SC1. Ability to mathematically formulate and investigate continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, analysis and interpretation.</p> <p>SC2. Ability to identify statistical patterns of non-deterministic phenomena, apply computational intelligence methods, statistical, neural network and fuzzy data processing, machine learning and genetic programming methods, etc.</p> <p>SC3. Ability to think logically, draw logical conclusions, use formal languages and models of algorithmic calculations, design, develop and analyze algorithms, evaluate their efficiency and complexity, solvability and unsolvability of algorithmic problems for adequate modeling of subject areas and creation of software and information systems.</p> <p>SC4. Ability to use modern methods of mathematical modeling of objects, processes and phenomena, to develop models and algorithms for numerical solution of mathematical modeling problems, to consider errors in approximate numerical solution of professional problems.</p> <p>SC5. Ability to carry out a formal description of operations research tasks in organizational, technical and socio-economic systems for various purposes, determine their optimal solutions, build optimal management models considering changes in the economic situation, optimize management processes in systems for various purposes and levels of hierarchy.</p> <p>SC6. Ability to systems thinking, apply the methodology of systems analysis to study complex problems of various natures, methods of formalization and solving systemic problems having conflicting goals, uncertainties and risks.</p> <p>SC7. Ability to apply theoretical and practical fundamentals of modeling methodology and technology to study characteristics and behavior of complex objects and systems, conduct computational experiments with processing and analysis of results.</p> <p>SC8. Ability to design and develop software using various programming paradigms: generalized, object-oriented, functional, logical, with appropriate models, methods and algorithms of calculations, data structures and control mechanisms.</p> <p>SC9. Ability to implement a multi-tiered computing model based on client-server architecture, including databases, knowledge and data storage, to perform distributed processing of large data sets on clusters of standard servers to meet users' computing needs, including on cloud services.</p> <p>SC10. Ability to apply methodologies, technologies and tools to manage the life cycle processes of information and software systems, information technology products and services in accordance with customer requirements.</p> <p>SC11. Ability to perform intelligent data analysis based on computational intelligence methods, including large and poorly structured data, their operational processing and visualization of analysis results in the process of</p>

	<p>solving applied problems.</p> <p>SC12. Ability to organize computing processes in information systems for various purposes, considering the architecture, configuration, and performance indicators of operating systems and system software.</p> <p>SC13. Ability to develop network software that operates based on various topologies of structured cabling systems, uses computer systems and data transmission networks, and analyzes the quality of computer network performance.</p> <p>SC14. Ability to apply methods and means of ensuring information security, develop and operate special software for protecting information resources of critical information infrastructure facilities.</p> <p>SC15. Ability to analyze and functionally model business processes, build and practically apply functional models of organizational, economic and production and technical systems, and methods for assessing the risks of their design.</p> <p>SC16. Ability to implement high-performance computing based on cloud services and technologies, parallel and distributed computing when developing and operating distributed parallel information processing systems.</p> <p><b>Competencies of educational and professional program</b></p> <p>SC17. Ability to identify, classify, evaluate, and describe processes in computer electronics devices and systems using analytical methods, modeling tools, and experimental research results.</p> <p>SC18. Ability to develop software for collecting, processing and transmitting information, organize interaction between hardware and software using communication protocols based on microcontrollers</p> <p>SC19. Ability to use knowledge of the basics of digital signal processing and ability to use them in the design of machine vision systems, processing of speech signals, and image analysis and synthesis.</p> <p>SC20. Ability to identify and use the necessary tools to organize the project development process, manage projects, assess the cost of technological products, and determine their economic and technological efficiency.</p>
<p><b>Special (professional, subject) competencies of a professional orientation (SCPO)</b></p>	<p><b>Track 1. Industrial Internet of Things</b></p> <p>SCPO 1.1. Ability to develop IoT systems and devices based on microprocessors and microcontrollers.</p> <p>SCPO1.2. Ability to identify elements, functional units and actuators for automation systems, embedded control systems based on industrial microprocessor controllers, and to calculate their parameters and characteristics.</p> <p>SCPO1.3 Ability to perform analysis and synthesis of automatic control systems, perform analysis of technological devices and processes as control objects; select control and management parameters based on technical characteristics, design features, and operating modes of technological equipment.</p> <p><b>Track 2. Internet of Things in Transportation</b></p> <p>SCPO 2.1. Ability to use modern methods and means of navigation in IoT systems in road transport.</p> <p>SCPO2.2. Ability to identify sensors, functional units and actuators for moving object control systems, and to calculate their parameters and characteristics.</p> <p>SCPO 2.3. Ability to develop algorithmic and software support for mobile object control devices, apply typical analytical methods and computer software tools to solve technical diagnostics problems of mobile object systems.</p>
<b>7 – Program learning outcomes</b>	
	<p>PLO1. Apply knowledge of basic forms and laws of abstract-logical thinking, the scientific knowledge methodology fundamentals, forms and meth-</p>



	<p>ods of extracting, analyzing, processing and synthesizing information in the subject area of computer science.</p> <p>PLO2. Use the modern mathematical apparatus of continuous and discrete analysis, linear algebra, and analytical geometry in professional activities to solve problems of a theoretical and applied nature in the process of designing and implementing informatization objects.</p> <p>PLO3. Use knowledge of the patterns of random phenomena, their properties and operations on them, models of random processes and modern software environments to solve problems of statistical data processing and build predictive models.</p> <p>PLO4 Use methods of computational intelligence, machine learning, neural network and fuzzy data processing, genetic and evolutionary programming to solve problems of recognition, prediction, classification, identification of control objects, etc.</p> <p>PLO5. Design, develop and analyze algorithms for solving computational and logical problems, evaluate the efficiency and complexity of algorithms based on the application of formal models of algorithms and computable functions.</p> <p>PLO6. Use methods of numerical differentiation and integration of functions, solving ordinary differential and integral equations, features of numerical methods and possibilities of their adaptation to engineering problems, have skills in software implementation of numerical methods.</p> <p>PLO7. Understand the principles of modeling organizational and technical systems and operations; use operations research methods, solving single- and multi-criteria optimization problems of linear, integer, nonlinear, stochastic programming.</p> <p>PLO8. Use the methodology of systems analysis of objects, processes and systems for the tasks of analysis, forecasting, management and design of dynamic processes in macroeconomic, technical, technological and financial objects.</p> <p>PLO9. Develop software models of object-oriented environments, choose a programming paradigm from the standpoint of convenience and quality of application for the implementation of methods and algorithms for solving problems in the field of computer science.</p> <p>PLO10. Use client-server application development tools, design conceptual, logical, and physical database models, develop and optimize queries for them, create distributed databases, data repositories and showcases, knowledge bases, including on cloud services, using web programming languages.</p> <p>PLO11 Possess skills in managing the life cycle of software, information technology products and services in accordance with the customer's requirements and limitations, be able to develop project documentation (feasibility study, technical specifications, business plan, agreement, contract).</p> <p>PLO12. Apply methods and algorithms of computational intelligence and data mining in classification, forecasting, cluster analysis, and search for associative rules using software tools to support multidimensional data analysis based on Data Mining, Text Mining, and Web Mining technologies.</p> <p>PLO13. To be proficient in system programming languages and methods of developing programs that interact with computer system components, to know network technologies, computer network architectures, to have practical skills in computer network administration technology and their software</p> <p>PLO14. Apply knowledge of methodology and CASE tools for designing complex systems, methods of structural analysis of systems, object-oriented design methodology in the development and study of functional models of organizational, economic and production and technical systems.</p>
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	<p>PLO15. Understand the concept of information security, the principles of secure software design, and ensure the security of computer networks in conditions of incompleteness and uncertainty of the source data.</p> <p>PLO16. Perform parallel and distributed computations, apply numerical methods and algorithms for parallel structures, parallel programming languages in the development and operation of parallel and distributed software.</p>
	<p><b>Track 1. Industrial Internet of Things</b></p> <p>PLO17. Understand the principles of operation for typical components of robotic mechanisms, design features and basic characteristics and parameters of mechanical parts of robots, use specialized software for programming robotics; use specialized hardware platforms for developing robots.</p> <p>PLO18. Apply theoretical and practical knowledge in the field of developing software and hardware platforms and IoT devices, and possess tools for research, design, construction, and reliability of IoT platforms.</p> <p>PLO19. Understand the concept of supervisory control and data acquisition systems, use software tools of modern SCADA systems, have practical skills in implementing SCADA communication with external applications (DBMS, spreadsheets, word processors, etc.), integrating SCADA into Internet of Things, and use tools for developing a human-machine interface.</p> <p><b>Track 2. Internet of Things in Transportation</b></p> <p>PLO20. Design, develop and analyze software, hardware and information support for automated transportation control and data acquisition systems, using the latest computer-integrated technologies.</p> <p>PLO21. Understand the principles of computational intelligence, machine learning, neural network and fuzzy data processing methods in monitoring, control and forecasting systems in transportation.</p> <p>PLO22 Apply theoretical knowledge and practical skills to research and implement control systems, data collection, and configuration of hardware and software platforms and IoT devices in transportation.</p>
<b>8 – Resource provision for implementation of the program</b>	
<b>Basic characteristics of human resources</b>	90% of scientific and pedagogical staff involved in teaching professionally oriented disciplines in specialty 122 Computer Science have scientific degrees and/or academic titles, 70% have experience of practical work in the specialty.
<b>Basic characteristics of logistics support</b>	Use of modern computer tools, software, modern equipment from leading manufacturers of IoT tools and systems, as well as laboratories equipped with modern devices.
<b>Basic characteristics of information and methodological support</b>	Using virtual learning environment of the Lviv Polytechnic National University and the author's developments of scientific and pedagogical workers, in particular textbooks and teaching aids recommended by the Scientific and Methodological Council of Lviv Polytechnic
<b>9 – Academic mobility</b>	
<b>National credit mobility</b>	Based on bilateral agreements between the Lviv Polytechnic National University and technical universities of Ukraine.
<b>International credit mobility</b>	Based on bilateral agreements between the Lviv Polytechnic National University and higher educational institutions of foreign partner countries.
<b>Education of foreign higher education applicants</b>	Possible, after learning the Ukrainian language course.

### 1. Distribution of the educational and professional program content by groups of components and training cycles

Sl. No.	Training cycle	The scope of educational workload for a higher education seekers (credits / %)		
		Mandatory Components of the Educational and Professional Program	Optional components of the educational and professional program	Total for the entire term of study
1	2	3	4	5
1.	General training cycle	74/30,83	6/2,5	80/33,33
2.	Professional training cycle	106/44,17	54/22,5	160/66,67
Total for the entire term of study		180/75	60/25	240/100

### 3. List of components of the educational and professional program

Code	Name of the component of educational and professional program	ECTS credits	Form of final control
1	2	3	4
<b>MANDATORY COMPONENTS (MC) OF THE EDUCATIONAL AND PROFESSIONAL PROGRAM</b>			
<i>I. General training cycle</i>			
MC1	Foreign language for a professional purpose	9	exam
MC2	History of statehood and culture of Ukraine	3	exam
MC3	Ukrainian language for a professional purpose	3	diff. test
MC4	Philosophy	3	exam
MC5	Algebra and geometry	6	exam
MC6	Discrete mathematics	6	exam
MC7	Mathematical analysis and differential equations	5	exam
MC8	Probability theory and mathematical statistics	5	diff. test
MC9	Numerical methods	5	exam
MC10	Mathematical methods of operations research	5	exam
MC11	Algorithms and programming	14	exam
MC12	Computer circuitry technology and architecture of computer systems	5	exam
MC13	Physics	5	exam
<b>Total per cycle I:</b>		<b>74</b>	
<i>II. Professional training cycle</i>			
<i>II. I. Professional training cycle (disciplines by specialty)</i>			
MC14	Teamwork in IT and presentation skills	7	exam
MC15	Database and knowledge base	5	exam
MC16	Algorithms and programming, part 3 with Course Work	6	exam
MC17	Operating systems	5	exam
MC18	Web technologies and web design	5	diff. test
MC19	Computer networks	4	exam
MC20	Information theory	4	diff. test
MC21	Information protection technologies	4	diff. test
MC22	Basics of artificial intelligence	6	exam
MC23	Systems analysis and business analysis with Course Work	6	exam
MC24	Cloud technology	4	diff. test

MC25	Basics of occupational health and safety life activities	3	diff. test
<b>Total per cycle II.I:</b>		<b>59</b>	
<b>II. II. Professional training cycle (disciplines by educational and professional program)</b>			
MC26	Computer electronics	6	exam
MC27	Microcontrollers, part 1 with Course Work	6	exam
MC28	Digital signal processing	5	exam
MC29	Analytical and non-relational databases	5	exam
MC30	Microeconomics of startups	3	diff. test
MC31	IT project management	5,5	exam
MC32	Project and technological practice	3	diff. test
<b>Total per cycle II.II:</b>		<b>33,5</b>	
<b>II.III. Practical training and final certification</b>			
MC33	Practice on the topic of a bachelor's qualification work	4,5	diff. test
MC34	Completion of bachelor's qualification work	6	
MC35	Defense of bachelor's thesis	3	
<b>Total per cycle II.III:</b>		<b>13,5</b>	
<b>Total per cycle II</b>		<b>106</b>	
<b>Total mandatory components:</b>		<b>180</b>	
<b>ELECTIVE COMPONENTS (EC) OF THE EDUCATIONAL AND PROFESSIONAL PROGRAM</b>			
<b>I. General training cycle</b>		<b>6</b>	
<b>Total per cycle</b>		<b>6</b>	
<b>I. Professional training cycle</b>			
<b>Elective Components of Track 1. Industrial Internet of Things</b>			
EC1.1.	Microcontrollers, part 2 with Course Project	8	exam
EC1.2.	Industrial controllers, sensors and actuators	4	exam
EC1.3.	Automatic control theory using computer technology	4	diff. test
EC1.4	Basics of robotics	5	exam
EC1.5.	SCADA systems and the Internet of Things	6	exam
EC1.6.	Data Mining	6	exam
EC1.7.	Interfaces and data transfer protocols	5	exam
EC1.8.	Design and construction of the Internet of Things platforms	5	diff. test
EC1.9	Documentation and software design patterns	5	exam
<b>Total per cycle:</b>		<b>48</b>	
<b>Elective Components of Track 2. Internet of Things in Transportation</b>			
EC2.1.	Software and hardware implementation of moving objects systems with Course Project	8	exam
EC2.2.	Sensors and actuators	4	exam
EC2.3.	Navigation systems of moving objects	4	diff. test
EC2.4	Information and communication systems in transport	5	exam
EC2.5.	Automation and computer-integrated technologies in transport	6	exam
EC2.6.	Methods of machine learning and data analysis	6	exam
EC2.7.	Intelligent technologies of moving objects	5	diff. test
EC2.8.	Internet of Things systems in transport	5	exam
EC2.9.	Computer diagnostics of moving object systems	5	exam
<b>Total per cycle:</b>		<b>48</b>	

<i>Elective components of other educational and professional programs</i>		
<i>Total:</i>	<b>6</b>	
<i>Total for professional training cycle:</i>	<b>54</b>	
<i>Total Elective Components</i>	<b>60</b>	
<b>Total for the educational and professional program:</b>	<b>240</b>	

#### 4. Form of certification of higher education applicants

<b>Forms of certification of higher education applicants</b>	Certification is conducted out in the form of a public defense of the qualification work.
<b>Requirements for qualification work</b>	<p>The qualification work involves solving a complex specialized task or practical problem using the theories and methods of the specialty, characterized by complexity and uncertainty of conditions, in the course of professional activities in the field of information technology.</p> <p>The qualification work must not contain academic plagiarism, falsification, or fabrication.</p> <p>The qualification work must be posted on the official website of Lviv Polytechnic National University or its structural subdivision, or placed in the repository of Lviv Polytechnic National University.</p>

**5. Matrix of correspondence of program competencies to the educational components of the educational and professional program  
«Systems engineering (Internet of Things)» of the bachelor's degree in “Computer Science”**

**Mandatory components**

CODE	General competencies (GC)																
	INT	GC1	GC2	GC3	GC4	GC5	GC6	GC7	GC8	GC9	GC10	GC11	GC12	GC13	GC14	GC15	GC16
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>	<i>14</i>	<i>15</i>	<i>16</i>	<i>17</i>	<i>18</i>
MC1	+					+											
MC2	+														+	+	
MC3	+				+												
MC4	+													+			+
MC5	+	+	+	+	+	+	+	+			+	+	+	+	+		
MC6	+	+	+	+	+	+	+	+			+	+	+	+	+		
MC7	+	+	+	+	+	+	+	+			+	+	+	+	+		
MC8	+	+	+				+	+	+		+	+	+	+	+		
MC9	+	+			+	+	+	+	+	+	+	+	+	+	+		
MC10	+	+	+	+			+	+	+		+	+	+	+	+		
MC11	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		
MC12	+	+	+				+	+	+			+					
MC13	+	+		+				+			+	+	+	+	+		
MC14	+		+		+				+	+							
MC15	+						+										
MC16	+		+				+	+				+	+				
MC17	+						+										
MC18	+			+			+										
MC19	+			+			+										
MC20	+			+			+										
MC21	+			+			+										
MC22	+			+			+										
MC23	+		+	+			+	+	+			+	+				
MC24	+		+	+				+									
MC25	+										+					+	
MC26	+			+			+										



CODE	General competencies (GC)																
	INT	GC1	GC2	GC3	GC4	GC5	GC6	GC7	GC8	GC9	GC10	GC11	GC12	GC13	GC14	GC15	GC16
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
MC27	+		+	+			+	+	+			+	+				
MC28	+			+			+										
MC29	+		+	+				+									
MC30	+		+	+				+					+				
MC31	+		+	+			+		+	+			+				
MC32	+			+				+				+	+				
MC33	+			+				+				+	+			+	
MC34	+	+	+	+			+		+	+	+		+	+	+		+
MC35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+

CODE	Special (professional, subject) competencies of the specialty (SC)																			
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13	SC14	SC15	SC16	SC17	SC18	SC19	SC20
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
MC1																				
MC2																				
MC3																				
MC4																				
MC5	+	+	+	+	+	+	+	+			+									
MC6	+	+	+	+	+	+	+	+			+									
MC7	+	+	+	+	+	+	+	+			+									
MC8	+	+	+	+	+	+	+	+			+									
MC9	+	+	+	+	+	+	+	+			+									
MC10	+	+	+	+	+	+	+	+			+									
MC11	+	+	+	+	+	+	+	+			+									
MC12	+		+																	
MC13	+	+	+	+	+	+	+	+			+									
MC14					+															
MC15	+	+	+	+	+	+	+	+		+	+									

CODE	Special (professional, subject) competencies of the specialty (SC)																			
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13	SC14	SC15	SC16	SC17	SC18	SC19	SC20
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
MC16	+	+	+	+	+	+	+	+			+									
MC17								+		+		+	+	+		+				
MC18								+	+	+		+								
MC19									+	+		+	+	+						
MC20	+	+																		
MC21		+					+			+				+						
MC22	+	+					+	+			+									
MC23	+	+	+	+	+	+						+			+					
MC24	+	+	+			+	+	+	+			+				+				
MC25					+									+						
MC26	+		+				+										+			
MC27			+				+	+		+								+		
MC28	+		+	+			+												+	
MC29		+	+	+				+	+							+				
MC30					+					+										+
MC31					+		+			+				+						+
MC32					+	+	+	+	+				+	+	+					+
MC33		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
MC34	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
MC35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

### Elective components

CODE	General competencies (GC)																
	INT	GC1	GC2	GC3	GC4	GC5	GC6	GC7	GC8	GC9	GC10	GC11	GC12	GC13	GC14	GC15	GC16
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>	<i>14</i>	<i>15</i>	<i>16</i>	<i>17</i>	<i>18</i>
EC1.1	+	+	+	+			+	+									
EC1.2	+	+	+	+			+		+								
EC1.3	+	+	+	+			+		+	+		+					
EC1.4	+	+	+	+			+										
EC1.5	+	+	+	+			+										
EC1.6	+	+	+	+			+	+									
EC1.7	+	+	+	+			+										
EC1.8	+	+	+	+			+					+					
EC1.9	+	+	+	+			+	+									
EC2.1	+	+	+	+			+	+									
EC2.2	+	+	+	+			+		+								
EC2.3	+	+	+	+			+		+	+		+					
EC2.4	+	+	+	+			+										
EC2.5	+	+	+	+			+										
EC2.6	+	+	+	+			+	+									
EC2.7	+	+	+	+			+										
EC2.8	+	+	+	+			+					+					
EC2.9	+	+	+	+			+	+									

CODE	Special (professional, subject) competencies of the specialty (SC)																			
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13	SC14	SC15	SC16	SC17	SC18	SC19	SC20
<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>7</i>	<i>8</i>	<i>9</i>	<i>10</i>	<i>11</i>	<i>12</i>	<i>13</i>	<i>14</i>	<i>15</i>	<i>16</i>	<i>17</i>	<i>18</i>	<i>19</i>	<i>20</i>	<i>21</i>
EC1.1	+							+												
EC1.2							+													
EC1.3	+																			
EC1.4	+		+	+																
EC1.5	+		+		+			+	+											
EC1.6		+									+									
EC1.7													+							
EC1.8	+									+										
EC1.9			+							+										
EC2.1	+		+					+												
EC2.2																				
EC2.3							+													
EC2.4	+		+						+											
EC2.5					+					+										
EC2.6	+	+																		
EC2.7		+								+										
EC2.8	+		+		+		+		+											
EC2.9							+													

CODE	Special (professional, subject) competencies of a professional orientation (SCPO)					
	SCPO1.1	SCPO1.2	SCPO1.3	SCPO2.1	SCPO2.2	SCPO2.3
1	2	3	4	5	6	7
EC1.1	+					
EC1.2		+				
EC1.3			+			
EC1.4						
EC1.5						
EC1.6						
EC1.7						
EC1.8						
EC1.9						
EC2.1				+		
EC2.2					+	
EC2.3						+
EC2.4						
EC2.5						
EC2.6						
EC2.7						
EC2.8						
EC2.9						

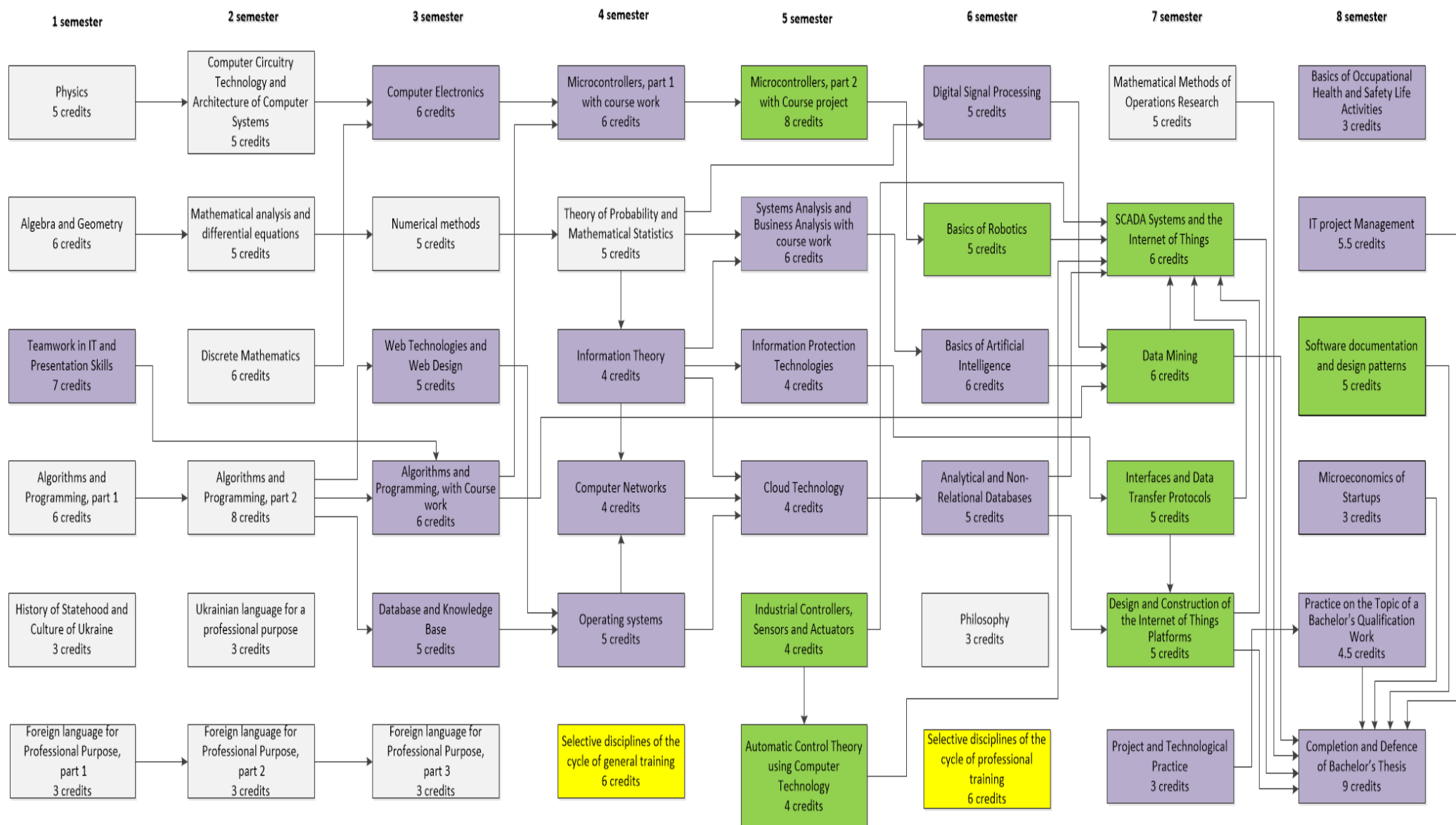
**Matrix of correspondence of Program Learning Outcomes with Mandatory/ Elective Components**

CODE	Mandatory Components																																		
	MC1	MC2	MC3	MC4	MC5	MC6	MC7	MC8	MC9	MC10	MC11	MC12	MC13	MC14	MC15	MC16	MC17	MC18	MC19	MC20	MC21	MC22	MC23	MC24	MC25	MC26	MC27	MC28	MC29	MC30	MC31	MC32	MC33	MC34	MC35
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	31	32	33	34	35
PLO1	+			+		+				+			+	+									+		+			+			+	+	+	+	+
PLO2					+	+	+		+											+				+				+				+	+	+	+
PLO3								+												+								+					+	+	+
PLO4																						+											+	+	+
PLO5						+					+						+						+										+	+	+
PLO6							+		+			+															+							+	+
PLO7										+		+																					+	+	+
PLO8										+		+											+							+			+	+	+
PLO9											+					+											+					+	+	+	+
PLO10															+			+						+					+				+	+	+
PLO11	+		+											+			+						+	+						+	+	+	+	+	+
PLO12																						+		+					+			+	+	+	+
PLO13																	+		+													+	+	+	+
PLO14												+								+			+			+				+	+	+	+	+	+
PLO15																			+		+												+	+	+
PLO16											+																						+	+	+
PLO17																																		+	+
PLO18																																		+	+
PLO19																																		+	+
PLO20																																		+	+
PLO21																																		+	+
PLO22																																		+	+



CODE	Elective Components of the Educational Program																	
	EC1.1	EC1.2	EC1.3	EC1.4	EC1.5	EC1.6	EC1.7	EC1.8	EC1.9	EC2.1	EC2.2	EC2.3	EC2.4	EC2.5	EC2.6	EC2.7	EC2.8	EC2.9
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
PLO1		+	+								+							
PLO2			+					+										
PLO3						+									+			
PLO4						+									+			
PLO5																		
PLO6																		
PLO7																		
PLO8																		
PLO9				+					+		+							
PLO10																		
PLO11	+							+	+									
PLO12						+									+			
PLO13					+		+			+		+	+	+		+		
PLO14	+							+	+									+
PLO15					+									+				
PLO16																		
PLO17				+						+	+							
PLO18	+	+		+	+		+	+		+	+		+				+	
PLO19		+			+													
PLO20												+	+	+		+	+	+
PLO21															+			
PLO22														+	+		+	+

## Structural and logical diagram of bachelor's training in specialty 122 Computer Science of Educational program “Systems Engineering (Internet of Things)” for track 1 - Industrial Internet of Things



## Structural and logical diagram of bachelor's training in specialty 122 Computer Science of Educational program “Systems Engineering (Internet of Things)” for Track 2 - Internet of Things in Transportation

