

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

"APPROVE"

Rector
Lviv Polytechnic
National University

_____ / Bobalo Y.J./
"_____" _____ 2022 p.

EDUCATIONAL AND SCIENTIFIC PROGRAM

of the third (educational and scientific) level of higher education

specialty 121 "Software Engineering"

areas of knowledge 12 "Information Technology"

**Qualification: Doctor of Philosophy in "Information Technology", specialty
"Software Engineering"**

Reviewed and approved
Academic Council of the
University

(protocol No _____
from "___" _____ 2022 p.)

Lviv 2022 p.

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Approved and entered into force by the Order of the Rector of the Lviv Polytechnic National University from "___" _____ 2022 No ____.

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LETTER of APPROVAL

educational and scientific program

Level of higher education	third (educational and scientific)
Field of study	12 <i>Information technology</i>
Speciality	121 <i>Software Engineering</i>
Qualification	Doctor of Philosophy

APPROVED

Scientific and methodical commission of specialty
121 *Software Engineering*
Protocol No 1
from "18" August 2022

Chairman of the NMC specialty 121
Software Engineering

_____ 2022 p.

Director of the Institute of Computer
Science
ta information technology
_____ M.O. Medicovsky
«__» _____ 2022 p.

RECOMMENDED

Scientific and Methodical Council of the
University
Protocol No _____
from " __ " _____ 2022 p.
Chairman of NMR
_____ A.G. Zagorodny

AGREED

Head of educational and methodical
department

_____ 2022 p.

Vice-Rector for Research

_____ Demidov I.V.
«__» _____ 2022 p.

Vice-Rector for Scientific and
Pedagogical Work

_____ Davydchak O.R.
«__» _____ 2022 p.

I. EDUCATIONAL COMPONENT OF THE EDUCATIONAL AND SCIENTIFIC PROGRAM

1. Profile of the Doctor of Philosophy program specialty 121 "Software Engineering"

1 – General information	
1	2
Full name of the higher education institution and structural unit	Lviv Polytechnic National University
Full name of the qualification in the original language	Ph.D. in <i>Information Technology</i> , majoring in <i>Software Engineering</i> Doctor of Philosophy in Information Technologies by Specialandty of Software Engineering
The official name of the educational and scientific program	Software Engineering Software Engineering
Type of diploma and scope of educational program	Diploma of Doctor of Philosophy, single, 43 credits and ECTS of the educational component of the educational and scientific program, the term of the educational component of the educational and scientific program – 2 years
Cycle/Level	NRK of Ukraine – level 8, FQ-EHEA – third cycle, EQF-LLL – 8 level
Prerequisites	Level of higher education "Master"
Language(s) of teaching	Ukrainian
Accreditation	Educational and scientific programs are accredited by NAQA on 19.11.2020, accreditation certificate No 748. The validity of the accreditation certificate is 01.07.2026.
Basic concepts and their definitions	The educational and scientific program uses the basic concepts and their definitions in accordance with the Law of Ukraine "On Higher Education" dated 01.07.2014 No. 1556-VII with amendments and additions, the Law of Ukraine "On Education" of 05.09.2017 No. 2145-VIII with amendments and additions, the Law of Ukraine "On Scientific and Scientific-Technical Activities" of 26.11.2015 No. 848-VII I, as amended, The procedure for training applicants for higher education of the degree of Doctor of Philosophy and Doctor of Science in higher education institutions (scientific institutions), approved by the Resolution of the Cabinet of Ministers of 23.03.2016 No. 261 with amendments and additions, the Procedure for conducting an experiment to award the degree of Doctor of Philosophy, approved by the Resolution of the Cabinet of Ministers of Ukraine dated 06.03.2019 No. 167, Methodical recommendations for the development of higher education standards approved by the Order Ministry of Education and Science of Ukraine dated 01.06.2017 No600 with amendments and additions, SHE in the specialty 121 Software Engineering for the third (educational and scientific) level of higher education, approved and put into effect by the order of the Ministry of Education and Science of Ukraine dated 25.05. 2022.
2 – The purpose of the educational and scientific program	

Purpose	Training of specialists who are able to produce new ideas, conduct fundamental and applied research, carry out scientific and pedagogical activities, and solve complex problems of professional and research and innovation activities in the field of software engineering, which involves a deep rethinking of existing and the creation of new holistic knowledge.
3 - Characteristics of the educational and scientific program	
Subject area (branch of knowledge, specialty)	Branch of knowledge 12 «Information technologies», specialty 121 "Software Engineering"
Orientation of the educational and scientific program	The educational and scientific program is based on the fundamental postulates of information technology and the results of modern scientific research in the field of engineering in relation to the theory and practice of the software development process. It is aimed at the development of theoretical, methodological and methodological and applied base for the creation of software systems with accentualization of the latest trends in the development of software engineering, which deepens the professional scientific worldview and provides the basis for scientific research and further professional and scientific activities.
Program Features	The educational and scientific program covers a wide range of modern innovative vectors of development of the theory and practice of software engineering and is determined by the individual curriculum of the graduate student.
4 – Suitability of graduates of the educational and scientific program before employment and further education	
Suitability for employment	In the positions of scientific and scientific-pedagogical workers in scientific institutions and institutions of higher education; employees of the highest qualification in research and design departments of IT enterprises.
Further training	Obtaining the degree of Doctor of Science and additional qualifications in the adult education system.
5 – Teaching and Assessment	
Teaching and learning	Combination of lectures and practical classes, pedagogical workshop, consulting with the supervisor and the scientific and pedagogical community with independent scientific and educational work
Evaluation	Exams, tests, current control
6 – Program competencies	
Integral competence (INT)	Ability to produce new ideas, solve complex problems of professional and / or research and innovation activities in the field of software engineering and related interdisciplinary areas, apply the methodology of scientific and pedagogical activity, conduct their own scientific research, the results of which have scientific novelty, theoretical and practical significance.
General Competences (GC)	ZK01. Ability to search, process and analyze information from various sources. ZK02. Ability to solve complex problems in the field of software engineering and related interdisciplinary areas based on a systematic scientific worldview and a common cultural outlook in compliance with the principles of professional ethics and academic integrity. ZK03. Ability to work in an international context. ZK04. Ability to present ideas, innovative developments and research results both in the scientific and professional community. .

Special (professional subject) competencies	<p>SK01. Ability to integrate knowledge from different fields, apply a systematic approach and take into account non-technical aspects when solving complex problems of software engineering and conducting research.</p> <p>SK02. Ability to identify, pose and solve research problems in the field of software engineering, evaluate and ensure the quality of the research performed.</p> <p>SK03. Ability to obtain new scientific results that create new knowledge and make an original contribution to the development of software engineering and related interdisciplinary areas.</p> <p>SK04. Ability to track trends in software engineering and critically rethink existing technologies.</p> <p>SK05. Ability to develop new and improve existing models, methods, tools, processes in the field of software engineering that ensure the development or provide new opportunities to software development and maintenance technologies.</p> <p>SK06. Ability to apply modern methodologies, methods and tools of software engineering in scientific, pedagogical and scientific activities</p> <p>SK07. Ability to initiate, develop and implement research and innovation projects in the field of software engineering, plan and organize the work of research teams.</p> <p>SK08. Ability to carry out and organize scientific and <u>pedagogical activities</u> in higher education institutions.</p>
7 – Programmatic learning outcomes	
Knowledge (ZN)	<p>PH01. Have advanced conceptual and methodological knowledge of software engineering and related interdisciplinary areas, as well as research skills sufficient to conduct scientific and applied research at the level of the latest world achievements in the relevant field, gain new knowledge and / or innovate.</p> <p>PH02. Plan and perform experimental and / or theoretical research on software engineering and related interdisciplinary areas using modern tools and compliance with the norms of academic and professional ethics, critically analyze the results of their own research and the results of other researchers in the context of the whole complex of modern knowledge about the problem under study.</p> <p>PH03. Offer new effective methods and models for the development, implementation, maintenance and quality assurance of software and management of relevant processes at all stages of the life cycle.</p> <p>PH04. Freely present and discuss with specialists and non-specialists the results of research, scientific and applied problems of software engineering in the state and foreign languages, publish research results in scientific publications in leading scientific journals.</p> <p>PH05. Apply modern tools and technologies for searching, processing and analyzing information, in particular, statistical methods of analyzing data of large volume and / or complex structure, specialized databases and information systems to improve the efficiency of software systems.</p> <p>PH06. Formulate and test hypotheses; use appropriate evidence to substantiate the conclusions, in particular, the results of theoretical analysis, experimental research and mathematical and/or computer modeling, and the available literary data.</p>
Skills (UM)	<p>RN07. Develop and research conceptual, mathematical and computer models of processes and systems to gain new knowledge and/or create innovative products in software engineering and related interdisciplinary areas.</p>

	<p>PH08. Deeply understand the general principles and methods of software engineering, as well as the methodology of scientific research, apply them in your own research and teaching practice.</p> <p>PH09. Formulate and solve problems of optimization, adaptation, forecasting, management and decision-making on processes, tools and resources of development, implementation, maintenance and operation of software.</p> <p>PH10. Analyze and evaluate the state and prospects of development of software engineering and information technology in general.</p> <p>PH11. Develop and implement scientific and/or innovative IT projects that allow you to rethink existing and create new holistic knowledge and/or professional practice and solve significant scientific and applied problems of software engineering in compliance with academic ethics and taking into account social, economic and legal aspects.</p> <p>PH12. To ensure the protection of intellectual property in the field of software engineering.</p> <p>PH13. Organize and implement the educational process in the field of software engineering, its scientific, educational, methodological and regulatory support, develop and teach special academic disciplines in higher education institutions.</p>
Communication (COM)	<ol style="list-style-type: none"> 1. Ability to communicate in a business scientific and professional language, apply different styles of speech, methods and techniques of communication, demonstrate a wide scientific and professional vocabulary. 2. Ability to use modern information and communication tools and technologies to ensure effective scientific and professional communications.
Autonomy and responsibility (AIV)	<ol style="list-style-type: none"> 1. Ability to independently carry out scientific research and make decisions. 2. Ability to formulate their own author's conclusions, suggestions and recommendations. 3. Ability to be aware of and be personally responsible for the results of the study.
8 – Resource support for the implementation of the educational program	
Specific characteristics of staffing	100% of scientific and pedagogical workers involved in teaching a cycle of disciplines that provide special (professional) competencies of a graduate student, have academic degrees and academic titles, are recognized professionals with experience in research, management or innovative work in the specialty
Specific characteristics of logistics	Use of modern technological means and platforms for software development and information and computing equipment.
Specific characteristics of information and methodological support	Use of the virtual learning environment of Lviv Polytechnic National University and the author's developments of scientific and pedagogical staff
9 – Academic mobility	
National credit mobility	On the basis of bilateral agreements between Lviv Polytechnic National University and Ukrainian universities
International credit mobility	On the basis of bilateral agreements between Lviv Polytechnic National University and educational institutions of partner countries
Training of foreign graduate students	Possible

3. Distribution of the content of the educational component of the educational and scientific program by groups of components and training cycles

№ s/n	Training cycles	The volume of the graduate student's study load (credits / %)		
		Mandatory components of the educational component	Selective components of the educational component	Just for the entire period teaching
1.	A cycle of disciplines that form general scientific competencies and universal skills of the researcher	21/49	3/7	24/56
2.	Cycle of disciplines that form professional competencies	10/23	6/14	16/37
3.	Cycle of disciplines of free choice of graduate student	-	3/7	3/7
Just for the entire period of study		31/72	12/28	43/100

The list of components of the educational component of the educational and scientific program

Code n/a	Components of the educational component	The volume of the component in ECTS loans	Form Final control
1	2	3	4
1. Mandatory components of the educational component			
<i>1.1. A cycle of disciplines that form general scientific competencies and universal skills of the researcher</i>			
OK1.1.	Philosophy and methodology of science	3	Exam
OK1.2.	Foreign Language for Academic Purposes, Part 1	4	Passed
OK1.3.	Foreign Language for Academic Purposes, Part 2	4	Exam
OK1.4.	Professional pedagogy	3	Exam
OK1.5.	Academic Entrepreneurship	4	Passed
OK1.6.	Pedagogical practice*	3	Passed
Total per cycle:		21	
<i>1.2. Cycle of disciplines that form professional competencies</i>			
OK2.1.	Methods of analysis and optimization of complex systems	4	Exam
OK2.2.	Research seminar on software engineering	3	Passed
OK2.3.	Innovative methods in software optimization	3	Passed
Total per cycle:		10	
Together, the required components of the specialty:		31	
2. Selective components of the educational component**			
<i>2.1. A cycle of disciplines that form general scientific competencies and universal skills of the researcher</i>			
VB1.1	Business foreign language	3	diff. Passed
VB1.2	Psychology of creativity and invention	3	diff. Passed
VB1.3	Management of scientific projects	3	diff. Passed
VB1.4	Technology of registration of grant applications and patent rights	3	diff. Passed
VB1.5	Rhetoric	3	diff. Passed
VB1.6	Modern invention in research activities	3	diff. Passed
VB1.7	Open scientific practices	3	diff. Passed
VB1.8	Academic integrity and quality of education	3	diff. Passed
VB1.9	Methodology of preparation of scientific publications	3	diff. Passed
VB1.10	Quality of higher education (formation of internal quality assurance systems)	3	diff. Passed
Total per cycle:		3	
<i>2.2. Cycle of disciplines that form professional competencies</i>			
VB2.1	Software Reliability Engineering	3	Exam
VB2.2	Management theory and optimal decision-making	3	Exam
VB2.3	Research methods in software engineering	3	Exam
VB2.4	Analysis, recognition and classification of images by artificial intelligence methods	3	Exam
VB2.5	Numerical methods for solving problems of mathematical physics in heterogeneous environments	3	Exam
VB2.6	Intelligent decision support systems	3	Exam
VB2.7	Modern approaches to the design of intelligent systems	3	Exam

VB2.8	Methods of computational intelligence for data classification and forecasting tasks	3	Exam
VB2.9	Neuro-like structures and ensembles for integral data analysis	3	Exam
VB2.10	Information and technological support of social and communication systems	3	Exam
Total per cycle:		6 (3+3)	
3. Disciplines of free choice of graduate student**			
VB3.1	Discipline of free choice of graduate student	3	diff. Passed
Together for the educational and scientific program:		43	

Note: * -pedagogical practice and can take place in the second or third year of study;

** - a postgraduate student has the opportunity to choose disciplines from paragraphs 2, paragraph 3 (selective and free choice), while the share of these subjects must be at least 25% of the total number of ECTS credits.

4. Matrix of compliance of program competencies with educational components

KOP	Competence												
	Inte-gambling	General competencies				Special (professional) competencies							
	INT	ZK1	ZK2	ZK3	ZK 4	SK01	SK02	SK03	SK04	SK05	SK06	SK07	SK08
OK1.1	•	•	•								•	•	
OK1.2	•			•	•								
OK1.3	•			•	•								
OK1.4	•		•	•									•
OK1.5	•			•								•	
OK1.6	•	•	•							•	•		
OK2.1	•	•	•			•	•			•	•		
OK2.2	•	•	•			•	•	•					
OK2.3	•	•	•	•		•	•	•	•	•		•	

Symbols: OK_i – compulsory discipline, VBi – selective discipline, and – number of discipline in the list of components of the educational component, INT – integral competence, ZK_j – general competence, FC_j – professional (special) competence, j – number of competence in the list of competencies of the educational component

5. Matrix of providing software learning outcomes with the relevant components of the educational component

Learning outcomes	Mandatory components of the educational component of the specialty								
	OK1.1	OK1.2	OK1.3	OK1.4	OK1.5	OK1.6	OK2.1	OK2.2	OK2.3
PH01	•							•	
RP02					•			•	
RP03									•
RP04		•	•						
RP05							•		•
RP06	•							•	
RP07							•		•
RP08				•		•		•	
RP09							•		•
RP10									•
PH11					•		•		
PH12					•				
RP13				•		•			
COM1	•	•	•	•	•	•	•	•	•
COM2	•	•	•	•	•	•	•	•	•
AIB1	•				•	•	•	•	•
AIV2	•	•	•	•	•	•	•	•	•
AIV3	•				•	•	•	•	•

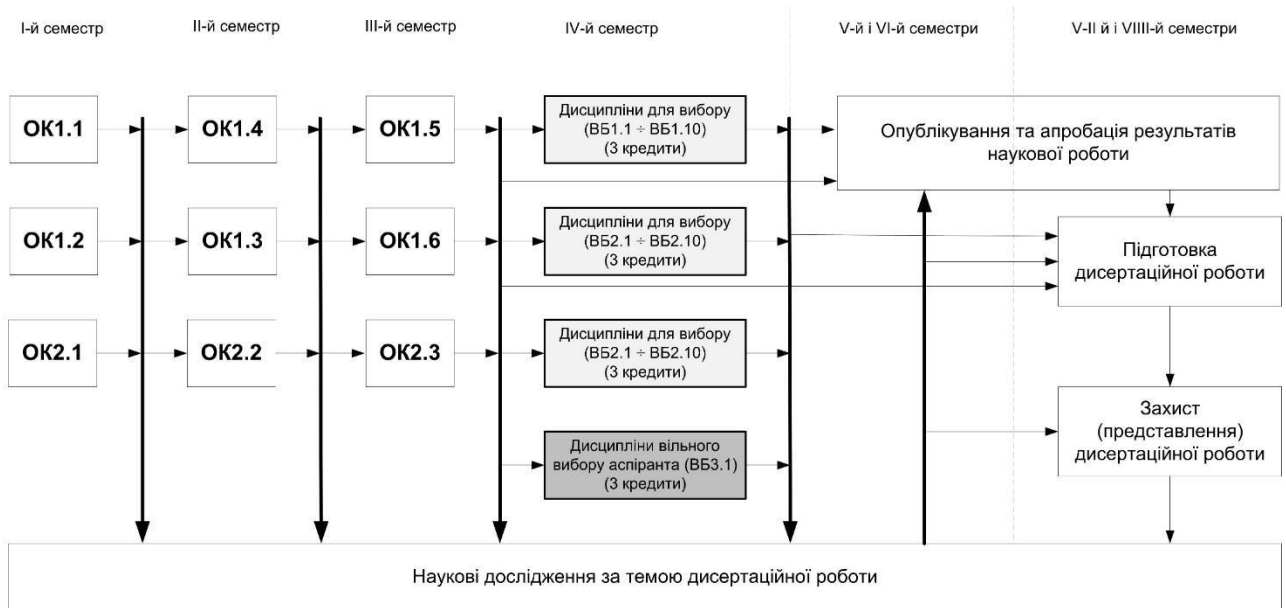
Symbols: OK1.i – compulsory discipline of the general training cycle, OK2.i – compulsory discipline of the professional training cycle, and – the number of discipline in the list of components of the educational component, RNm – program results (knowledge), KOMm – program results (communication), AiVm – program results (autonomy and responsibility), m – number of the program result in the list of program results of the educational component.

Matrix of compliance with the results of training and competencies defined by the Standard.

Results teaching	Competence											
	Integral competence The ability to produce new ideas, solve complex problems of professional and / or research and innovation activities in the field of software engineering and related interdisciplinary areas, apply the methodology of scientific and pedagogical activity, conduct their own scientific research, the results of which have scientific novelty, theoretical and practical significance.											
	General competencies				Special (professional, subject) competencies							
	ZK01	ZK02	ZK03	ZK04	SK01	SK02	SK03	SK04	SK05	SK06	SK07	SK08
PH01	+			+	+		+	+				
RP02	+	+	+			+	+		+	+	+	
RP03		+				+	+		+	+		
RP04			+	+							+	+
RP05									+	+		
RP06		+				+	+					
RP07		+							+			
RP08	+					+				+	+	
RP09	+	+			+	+	+		+		+	
RP10	+				+	+		+			+	
PH11			+			+					+	
PH12	+						+				+	
PH13	+			+	+							+

6. Structural and logical scheme of the educational and scientific program of the third (educational-scientific) level of higher education

specialty 121 "Software Engineering"



II. Scientific component of the educational and scientific program

The scientific component of the educational and scientific program involves the graduate student performing his own scientific research under the guidance of one or two supervisors and formatting his results in the form of a dissertation.

The dissertation for the degree of Doctor of Philosophy is an independent detailed research that offers the solution of an actual scientific and applied problem in the specialty 073 "Management", the results of which are characterized by scientific novelty and practical value and are published in the relevant publications.

The scientific component of the educational and scientific program is drawn up in the form of an individual plan of scientific work of the graduate student and is an integral part of the postgraduate curriculum.

An integral part of the scientific component of the educational and scientific program of postgraduate studies is the preparation and publication of scientific articles, speeches at scientific conferences, scientific professional seminars, round tables, symposia, etc.

Research topics in the specialty 121 "Software Engineering":

1. Improvement of software systems development processes.
2. Methods of organizing effective computing in computer systems.
3. Methods and tools for analysis and design of software systems.
4. Automated systems for processing knowledge data and management in various subject areas.
5. Methods of researching the functioning of computer and software systems.
6. Evaluation, analysis and improvement of the quality of software systems.
7. Evaluation and analysis of the reliability of software systems.
8. Development of new numerical-analytical approaches to solving problems of mathematical physics.
9. Automation of thermal design of microelectronic systems.
10. Research and implementation of thermal design algorithms in systems with distributed calculations.
11. Mathematical modeling of stationary, non-stationary and well-established physical processes of different nature.
12. Mathematical and software for image processing.
13. Mathematical and software for solving intractable combinatorial problems of high dimension.
14. Methods and means of fuzzy clustering of data of different nature.
15. Encoding and recognition of visual information, storage and efficient search of large volumes of data.
16. Development of methods for analyzing, designing and optimizing interrelated software systems of various nature.
17. Design of software systems operating in conditions of uncertainty.
18. Development of the theory of information modeling during the development of software systems.

19. Development of problem-oriented technologies of intelligent systems.
20. Creation of computer technologies for recognition and classification in software systems.
21. Mathematical and software of information modeling of problem areas based on databases.
22. Computer and linguistic support of distance learning using database technologies.
23. Methods and means of modeling complex social processes on the Internet based on space-time data models.
24. . Models, methods for ensuring the quality and safety of software systems, taking into account their complexity, architecture and implementation technologies.
25. Mathematical and software for searching, storing and recognizing images based on artificial intelligence methods.
26. Mathematical and software for solving intractable combinatorial problems of high dimension.
27. Creation of computer technologies for recognition and classification in software systems.
28. Development of new numerical-analytical approaches to solving problems of mathematical physics.
29. Mathematical modeling of stationary, non-stationary and well-established physical processes of different nature.
30. Methods, models and algorithms for creating software systems with virtual and augmented reality.

III. Certification of graduate students

Certification of applicants for higher education of the degree of Doctor of Philosophy is carried out by a specialized academic council, permanent or formed for a one-time defense, on the basis of public defense of scientific achievements in the form of a thesis.

A prerequisite for admission to protection is the successful implementation by the graduate student of his individual curriculum.

The volume of the main text of the thesis should be 4.0 – 5.5 author's sheets.