

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

APPROVED BY
Rector of Lviv Polytechnic
National University

_____ Yuriy BOBALO
«_____» _____ 2023 p.

EDUCATIONAL AND SCIENTIFIC PROGRAM

Telecommunications and radio engineering

level of higher education	third (educational and scientific)
field of knowledge	17 Electronics, automation and electronic communications
specialty	172 Electronic communications and radio engineering
educational program	Telecommunications and radio engineering
educational qualification	Doctor of Philosophy in Electronics, Automation and Electronic Communications, specialty 172 Electronic Communications and Radio Engineering

Considered and approved
at a meeting of the Academic Council of
Lviv Polytechnic National University
«___» _____ 2023
Protocol № _____

Developed by the working group for quality assurance of the educational and scientific program, which provides training for applicants at the third (educational and scientific) level of higher education in the specialty 172 *Electronic Communications and Radio Engineering* consists of:

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«_____» _____ 2023 № _____.

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LETTER OF AGREEMENT
educational and scientific program

Level of higher education	Third (educational and scientific)
Field of knowledge	17 <i>Electronics, automation and electronic communications</i>
Specialty	172 <i>Electronic communications and radio engineering</i>
Qualification	Doctor of Philosophy

APPROVED

Scientific and methodical commission of specialty 172 *Electronic communications and radio engineering*

Protocol No. _____
«__» _____ 2023

Head of the scientific and methodological commission of the specialty 172 *Electronic communications and radio engineering*

«__» _____ 2023

Head of the Institute of Telecommunications, Radioelectronics and Electronic Engineering

B.M. Strykhaliuk
«__» _____ 2023

RECOMMENDED

Scientific and methodological council of Lviv Polytechnic National University
Protocol No

«__» _____ 2023

A.H. Zahorodnyi

AGREED

Vice-rector for scientific work

Demydov I.V.
«__» _____ 2023

Vice-rector for scientific and pedagogical work

Davydchak O.R.
«__» _____ 2023

Head of the Department of Doctoral and Postgraduate Studies

Mukan O.V.
«__» _____ 2023

I. EDUCATIONAL COMPONENT OF THE EDUCATIONAL AND SCIENTIFIC PROGRAM

1. Profile of the Doctor of Philosophy program in the field of knowledge 17 *Electronics, automation and electronic communications in specialty 172 Electronic communications and radio engineering*

1 – General information	
1	2
Full name of the higher education institution and structural unit	Lviv Polytechnical National University
The full title of the qualification in the original language	Doctor of Philosophy in Electronics, Automation and Electronic Communication, in specialty 172 Electronic Communications and Radio Engineering
The official name of the educational program	Telecommunications and Radio Engineering
Type of diploma and scope of the educational program	Diploma of Doctor of Philosophy, single, 43 ECTS credits, term of the educational component of the educational and scientific program 2 years
Cycle/level	NFQ –level 8, FQ-EHEA – third cycle, EQF-LLL – level 8
Prerequisites	Level of higher education «Master's degree»
Language(s)	Ukrainian language
Basic concepts and their definitions	In the educational and scientific program, the basic concepts and their definitions are used in accordance with the Law of Ukraine "On Higher Education" of 01.07.2014 № 1556-VII with amendments and additions, the Law of Ukraine "On Scientific and Scientific-Technical Activity" of 26.11.2015 № 848-VIII with amendments and additions, the Procedure for the preparation of applicants for the degree of Doctor of Philosophy and Doctor of Science in higher education institutions (scientific institutions), approved by the Cabinet of Ministers of 23.03.2016 № 261
2 – The purpose of the educational program	
	To provide theoretical knowledge and practical skills sufficient for the successful implementation of original research in the field of <i>Electronics and Telecommunications</i> in the specialty of <i>Electronic Communications and Radio Engineering</i> , aimed at obtaining new scientific knowledge, preparing and defending a dissertation, further professional and scientific activities.
3 - Characteristics of the educational program	
Subject area (field of	Field of knowledge 17 <i>Electronics, automation and</i>

knowledge, specialty)	<i>electronic communications, specialty 172 Electronic communications and radio engineering</i>
Orientation of the educational program	Fundamental and applied research in the field of life cycle design and improvement, optimization and restructuring of telecommunication and radio engineering systems and networks, their mathematical, software, hardware and information support based on the improvement and development of new models, methods, technologies, in particular, optoelectronic element base and network architecture elements to ensure the specified performance characteristics and properties. Further research and/or teaching career is possible.
The main focus of the educational program	Research in the field of telecommunications and radio engineering. Keywords: telecommunications, radio engineering, telecommunication systems, radio engineering systems, radio communication, systems, complexes, devices, television, radio broadcasting, control, electronic equipment.
Features and differences	The program is implemented under the auspices of the teams of scientific schools. A wide range of in-depth lecture courses and doctoral seminars. The scientific component of the educational and scientific program is determined by the individual study plan of the graduate student.
4 – Suitability of graduates of the educational program to employment and further education	
Suitability for employment	Jobs at research institutes of the National Academy of Sciences of Ukraine, higher education institutions of the Ministry of Education and Science of Ukraine, research centres and high-tech companies, electronics and telecommunications enterprises.
Further education	Lifelong learning for excellence in scientific and other activities (e.g., highly specialized technological fields). Further education in a doctoral study is possible in areas close to the field of knowledge "Electronics, Automation and Electronic Communications", computer science. Professional development in scientific research institutes of the National Academy of Sciences of Ukraine, leading universities, and high-tech company research centers.

5 - Teaching and assessment

Teaching and learning	At the beginning, there is close scientific supervision, support from the scientific advisor, and guidance and consultation from other colleagues in the research group, including postdoctoral fellows, more experienced postgraduate, and technical staff. The study of scientific methodology is conducted through various interactive courses offered by the doctoral program. Lecture courses, seminars, consultations, self-study in the library and online, literature reviews, and individual consultations are part of the training process. The preparation of the dissertation work is also included.
Assessment	The assessment methods include test exam, written exams (covering both problem-solving and scientific tasks), seminars, and scientific reports with evaluation of the achievements. The defense of the dissertation work involves participation of scholars from other universities and includes an oral examination.

6 – Program competencies

Integral competence (INT)	The ability to solve complex specialized scientific problems and practical problems in the course of research activities in the field of telecommunications and radio engineering or in the process of study, which involves the application of theories and methods of telecommunications and radio engineering and is characterized by complexity and uncertainty of conditions.
General competences (GC)	<ol style="list-style-type: none">1) Mastering general scientific (philosophical) competencies aimed at forming a systematic scientific outlook, professional ethics and general cultural outlook; application of modern information technologies in scientific activities (work with scientometric databases, automatic generation of references to literary sources).2) Acquisition of language competencies sufficient to present and discuss the results of their scientific work in a foreign language in oral and written form, as well as to fully understand foreign language scientific texts in the relevant specialty, the use of modern information technologies (presentation of scientific results).3) Acquiring universal research skills, in particular, organizing and conducting training sessions, using modern information technologies (working with

	<p>virtual learning environment, Microsoft Teams, Zoom, etc.).</p> <p>4) Acquisition of universal research skills, including oral and written presentation of research results in Ukrainian, management of research projects and/or preparation of proposals for research funding, registration of intellectual property rights, and the use of modern information technologies.</p> <p>5) Acquiring systematic knowledge of modern methods of research in the field of telecommunications and radio engineering, as well as in related fields.</p> <p>6) Mastering critical analysis, evaluation and synthesis of new ideas.</p> <p>7) Mastering the ability to initiate and conduct original research, identify current scientific problems, search and critically analyze information, produce innovative constructive ideas and apply non-standard approaches to solving complex and atypical problems.</p>
<p>Special (professional) competencies (PC)</p>	<p>1) Research abilities in the field of telecommunications and radio engineering. Competence to perform original research in telecommunication and radio engineering systems and achieve scientific results that create new knowledge, paying special attention to current tasks/problems and using the latest scientific methods.</p> <p>2) Technological abilities. Competence in the use of scientific equipment and technologies related to the field of telecommunications and radio engineering.</p> <p>3) Design abilities. Competence in designing units and elements of telecommunications and radio engineering systems, skills in applying synthesis elements, taking into account all aspects of the task, including creation, adjustment, operation, maintenance and disposal.</p> <p>4) Data analysis skills. Competence to model and analyze data from experiments on the study of telecommunications and radio engineering systems using computing resources.</p> <p>5) Ability to criticize and evaluate. Competence to interpret the results of experiments and participate in discussions with experienced scientists on the scientific significance and potential implications of the results.</p>

7 – Programme learning outcomes

Knowledge (KN)	<ol style="list-style-type: none">1) Ability to demonstrate in-depth knowledge and understanding of the scientific and mathematical principles underlying telecommunications and radio engineering, including methods of conducting experiments, data collection and processing, modeling methods and means;2) Knowledge of applied technologies of telecommunication and radio engineering systems, the level of this knowledge should be sufficient to conduct research at the level of the latest world achievements and aimed at their expansion and deepening;3) Ability to demonstrate knowledge of the basics of economics and research project management.
Skills (SK)	<ol style="list-style-type: none">1) Ability to review and search for information in specialized literature using a variety of resources: journals, databases, online resources;2) Ability to conduct specialized scientific seminars and publish scientific articles in major scientific journals in the field;3) Ability to apply knowledge and skills to identify, formulate and solve technical problems of the specialty, using known and created methods;4) Ability to apply knowledge and understanding to solve problems of synthesis and analysis in systems that are characteristic of the chosen specialization;5) Ability to think systematically and apply creative abilities to the formation of fundamentally new ideas;6) Ability to prepare and successfully defend a dissertation based on individual research, as well as to use (and recognize) the results of other members of the research team;7) Ability to work effectively both individually and as part of a team;8) Ability to identify, classify and describe the operation of systems and their components;9) Ability to combine theory and practice, as well as to make decisions and develop a strategy for solving scientific problems in the specialty, taking into account universal human values, public, state and industrial interests;10) Ability to perform relevant experimental research and apply research skills on professional topics;11) Ability to evaluate the results obtained and to defend the decisions made with arguments;

	12) Ability to create large-scale software products in various programming languages in accordance with the needs of the dissertation research, as well as to adapt, improve and embed software products originally intended for another purpose.
Communication (COM)	1) Ability to clearly and effectively describe intensive, in-depth and detailed results of scientific work; 2) Ability to communicate, including oral and written business communication in Ukrainian and a foreign (English) language at a sufficient professional level; 3) Ability to use a variety of methods, including information technology, to communicate effectively at professional and social levels.
Autonomy and responsibility (AiB)	1) Ability to adapt to new situations and make decisions; 2) Ability to recognize the need for lifelong learning in order to deepen the acquired and acquire new professional knowledge; 3) Ability to take responsibility for the work performed and achieve the goal in compliance with the requirements of professional ethics; 4) Ability to demonstrate an understanding of the basic principles of occupational health and safety and their application.
8 – Resource support for program implementation	
Specific characteristics of staffing	100% of the teaching staff involved in teaching the disciplines of the educational and research program have academic degrees in their specialty.
Specific characteristics of the material and technical support	Use of modern equipment from leading telecommunications and radio engineering companies, including Nokia, Lucent Technologies, Siemens, Rode and Schwarz, Texas Instruments, Cypress Systems, etc.
Specific characteristics of informational and methodological support	The use of the virtual learning environment of the Lviv Polytechnic National University and author's developments of the teaching staff.
9 - Academic mobility (regulated by the Resolution of the Cabinet of Ministers of Ukraine No. 579 "On Approval of the Procedure for the Implementation of the Right to Academic Mobility" dated August 12, 2015)	
National credit mobility	Based on bilateral agreements between Lviv Polytechnic National University and technical universities in Ukraine.

International credit mobility	Under the EU Erasmus+ program, based on bilateral agreements between Lviv Polytechnic National University and partner educational institutions of other countries.
Education of foreign students of higher education	Is possible.

2. Distribution of content of the educational component of the educational and scientific program by component groups and preparation cycles

№	Preparation cycles	The amount of study load of a postgraduate student (credits/%)		
		Mandatory components of the educational program	Elective components of the educational program	In total for the entire term teaching
1.	Cycle of disciplines that form general scientific competences and universal skills of the researcher	21/49	3/7	24/56
2.	Cycle of disciplines forming professional competences	10/23	6/14	16/37
3.	The cycle of disciplines of free choice of a postgraduate student	-	3/7	3/7
In total or the entire term teaching		31/72	12/28	43/100

3. List of components of the educational component of the educational and research program

Code of discipline	Components of the educational component	Number of credits	Final control form
1	2	3	4
1. Mandatory components of the educational program			
<i>1.1. Cycle of disciplines that form general scientific competencies and universal skills of a researcher</i>			
MD1.1.	Philosophy and Methodology of Science	3	exam
MD1.2.	English Language for Academic Purposes, part 1	4	test exam
MD1.3.	English Language for Academic Purposes, part 2	4	exam
MD1.4.	Professional Pedagogy	3	test exam
MD1.5.	Academic Entrepreneurship	4	test exam
MD1.6.	Teaching Practice	3	test exam
Total per cycle:		21	
<i>1.2. Cycle of disciplines forming professional competences</i>			
MD2.1.*	Telecommunication and Radioelectronic Devices and Systems Optimization Methods	3	test exam
MD2.2.*	Scientific Research Methods in Telecommunications	4	exam
MD2.3.	Mathematical Modelling and Prediction of the Experiment	3	test exam
Total per cycle:		10	
2. Elective components of the educational program			
<i>2.1. Cycle of disciplines that form general scientific competencies and universal skills of a researcher</i>			
SD1.1	Business Foreign Language	3	test exam
SD1.2	Psychology of Creativity and Invention	3	test exam
SD1.3	Management of Scientific Projects	3	test exam
SD1.4	Technology of Processing Grant Applications and Patents	3	test exam
SD1.5	Rhetoric	3	test exam
SD1.6	Modern Inventive Management in Scientific and Research Activities	3	test exam
SD1.7	Open Science Practices	3	test exam
SD1.8	Academic Integrity and Education Quality	3	test exam
SD1.9	Methodology of Scientific Paper Publishing	3	test exam
SD1.10	Quality of Higher Education (Internal Quality Assurance Systems)	3	test exam
Total per cycle:		3	
<i>2.2. Cycle of disciplines that form professional competencies **</i>			
SD2.1	Technologies and Models of Information and Communications Systems	3	exam
SD2.2	Fundamentals of Photonics	3	exam
SD2.3	Planning and Design of Multiservice Platforms	3	exam
SD2.4	Development and Functioning of Radio-Electronic Devices and Systems of Gigo- and Terahertz Range	3	exam
SD2.5	Algorithms Modeling Technology of Information Systems Functioning	3	exam
SD2.6	Laser Technologies	3	exam
SD2.7	Plasmonics	3	exam
SD2.8	Modern Computer Means of Radioelectronic Devices and Systems Research	3	exam
SD2.9	Digital Signal Processing	3	exam
SD2.10	Random Processes Theory and Methods of Analysis	3	exam
Total per cycle:		6	
3. Disciplines at the discretion of the graduate student***			
SD3.1	Discipline of free choice of a postgraduate student	3	test exam
Total per cycle:		3	
TOTAL		43	

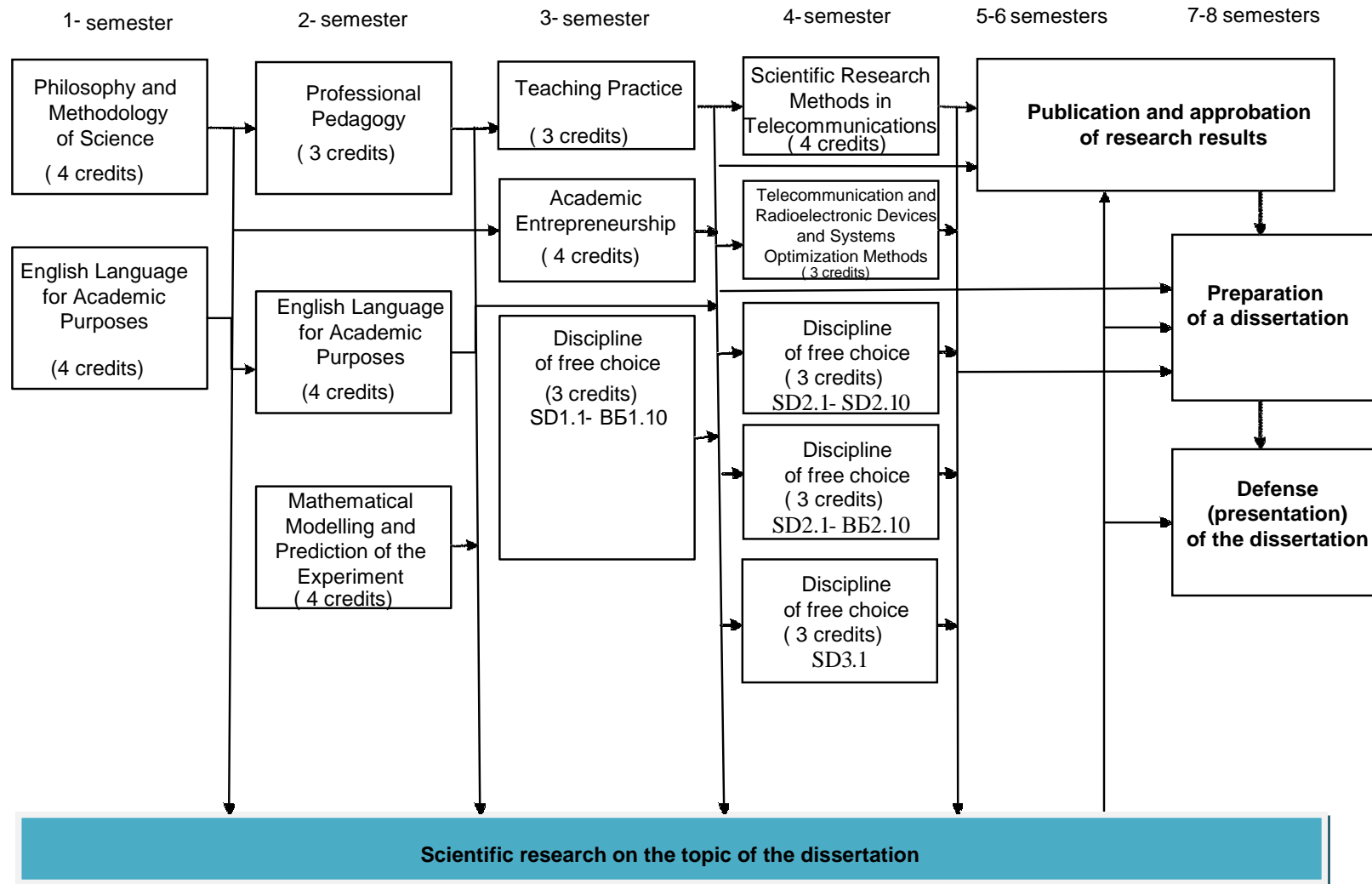
Note:

* - the list of disciplines that form professional competencies is offered common to the program of related fields and specialties;

** - the list of elective disciplines that form professional competencies should contain ten disciplines, of which the graduate student chooses two;

*** - a postgraduate student can choose disciplines taught at Lviv Polytechnic National University or other domestic (foreign) higher education institutions (research institutions) at all levels.

4. Structural and logical diagram of the educational and scientific program of the third (educational and scientific) level of higher education in the specialty 172 "Electronic Communications and Radio Engineering"



5. Correspondence matrix of program competencies to the educational components of the educational and scientific program

	MD1.1	MD1.2	MD1.3	MD1.4	MD1.5	MD1.6	MD2.1	MD2.2	MD2.3	SD1.1	SD1.2	SD1.3	SD1.4	SD1.5	SD1.6	SD1.7	SD1.8	SD1.9	SD1.10	SD2.1	SD2.2	SD2.3	SD2.4	SD2.5	SD2.6	SD2.7	SD2.8	SD2.9	SD2.10
INT				•			•	•	•		•	•	•	•		•	•	•	•	•	•	•	•	•	•	•	•	•	•
GC1	•									•	•	•	•	•	•	•	•	•	•										
GC2		•	•							•	•	•	•	•	•	•	•	•	•										
GC3				•		•				•	•	•	•	•	•	•	•	•	•										
GC4					•					•	•	•	•	•	•	•	•	•	•										
GC5							•	•	•											•	•	•	•	•	•	•	•	•	
GC6							•	•	•											•	•	•	•	•	•	•	•	•	
GC7							•	•	•												•	•	•	•	•	•	•	•	
PC1							•	•	•											•	•	•	•	•	•	•	•	•	
PC2								•												•	•	•	•	•	•	•	•	•	
PC3							•	•	•											•	•	•	•	•	•	•	•	•	
PC4							•	•	•											•	•	•	•	•	•	•	•	•	
PC5								•	•																			•	

Conventional designations:

• competence to be acquired, MD_i – mandatory discipline discipline, SD_i – selective discipline, i – discipline number in the list of components of the educational component, INT – integral competence, GC_j – general competence, PC_j – professional (special) competence, j – competence number in the list of competences educational component.

6. Matrix of provision of programmatic learning outcomes with relevant components of the educational program

	MD1.1	MD1.2	MD1.3	MD1.4	MD1.5	MD1.6	MD2.1	MD2.2	MD2.3	SD1.1	SD1.2	SD1.3	SD1.4	SD1.5	SD1.6	SD1.7	SD1.8	SD1.9	SD1.10	SD2.1	SD2.2	SD2.3	SD2.4	SD2.5	SD2.6	SD2.7	SD2.8	SD2.9	SD2.10
KN1								•	•											•	•	•	•	•	•	•	•	•	•
KN2								•	•											•	•	•	•	•	•	•	•	•	•
KN3					•							•			•	•			•										
SK1	•	•	•							•	•		•	•	•	•	•	•											
SK2	•	•	•					•	•	•								•	•								•	•	
SK3	•							•	•											•	•	•	•	•	•	•	•	•	•
SK4	•							•	•											•	•	•	•	•	•	•	•	•	•
SK5	•				•			•	•		•					•				•	•	•	•	•	•	•	•	•	•
SK6											•				•	•	•			•	•	•	•	•	•	•	•	•	•
SK7		•	•		•			•	•	•	•		•	•	•	•	•	•		•	•	•	•	•	•	•	•	•	•
SK8	•						•	•	•		•									•	•	•	•	•	•	•	•	•	•
SK9	•				•		•	•	•			•	•	•	•	•	•	•	•										
SK10							•	•	•											•	•	•	•	•	•	•	•	•	•
SK11							•				•									•	•	•	•	•	•	•	•	•	•
SK12											•									•	•	•	•	•	•	•	•	•	•
COM1		•	•	•		•		•	•	•	•	•	•	•	•		•	•	•										•
COM2		•	•	•		•				•	•	•				•				•									
COM3				•		•		•	•		•																		•
AiB1				•		•					•	•	•	•	•	•	•	•	•										
AiB2	•										•									•									
AiB3	•			•		•					•																		
AiB4				•		•						•								•	•	•	•	•	•	•	•	•	•

Conventional designations:

•the program result that is provided, MDi – mandatory discipline, SDi – selective discipline, i – number of the discipline in the list of components of the educational component, KNm – program results (knowledge), SKm – program results (skills), m – number of the program result in the list of program results educational component

II. SCIENTIFIC COMPONENT OF THE EDUCATIONAL AND SCIENTIFIC PROGRAM

The scientific component of the educational and scientific program involves the conduct of the postgraduate student's own research under the guidance of one or two academic supervisors and the documentation of its results in the form of a dissertation.

The dissertation for the degree of Doctor of Philosophy is an independent and comprehensive research study that offers a solution to a relevant scientific problem in the field of specialty 172 Electronic Communications and Radio Engineering. Its results are characterized by scientific novelty and practical value and are published in relevant publications.

The scientific component of the educational and scientific program is formalized as an individual research plan for the postgraduate student and is an integral part of the postgraduate curriculum.

An integral part of the scientific component of the postgraduate educational and scientific program is the preparation and publication of scientific articles, participation in scientific conferences, scientific seminars, roundtable discussions, and symposiums.

Research topics in the specialty 172 *Electronic Communications and Radio Engineering*:

1. Design of telecommunication systems with guaranteed quality of service and scalability.
2. Theory, models and methods of ensuring fault tolerance and security in telecommunication systems and networks.
3. Development of dynamic models of TCP/IP networks taking into account nonlinear processes of information exchange.
4. Models and methods for analyzing and ensuring the structural and functional stability of telecommunication systems and networks.
5. Hierarchical coordination models and methods for increasing the scalability of routing and queue management solutions at the nodes of telecommunication systems.
6. Development of models and methods of resource allocation in geographically distributed optical networks (including IP-over-DWDM technology) according to the criterion of energy saving.
7. Models and methods for creating, verifying and supporting information and communication services in telecommunication systems.
8. Development of engineering methods for improving the process of monitoring the level of service quality in geographically distributed multiservice telecommunication systems; development of models and methods for ensuring the required values of reliability and availability of services in territorially distributed converged telecommunication systems.
9. Development of methods for ensuring the resilience of service-oriented systems to network attacks of various types within territorially distributed converged telecommunication systems with QoS.

10. Development of methods for designing wireless Ad-Hoc and Mesh networks, optimization of traffic management and frequency resource allocation in networks of this class.

11. Development of methods for increasing the scalability of cognitive radio networks within converged telecommunication systems by optimizing the allocation of frequency resources in them.

12. Theory, models and methods of frequency-temporal design and planning of LTE, WiMAX networks, etc.

13. Models and methods of spatio-temporal signal processing of wireless telecommunication systems.

14. Theory, models and methods of designing plasma systems, their application.

15. Applied research in the field of laser technology.

16. Theory and models of photonic technologies, their application.

17. Increasing the noise immunity of software-controlled synchronization devices.

18. Improving the accuracy of measurement of ultra-low level signals.

19. Improving the energy efficiency of signals in radio engineering and telecommunication systems.

20. Increasing the spectral efficiency of signals in radio engineering and telecommunication systems.

21. Ensuring the reliability of complex radio engineering systems.

22. Providing redundancy in complex radio engineering systems.

23. Optimization of technological processes for the production of radio electronic equipment, radio engineering devices and systems.

24. Ensuring defect-free production of electronic equipment.

25. Prediction of the behavior of complex radio engineering and telecommunication systems.

26. Development of models and evaluation of reliability of electronic devices and systems.

27. Creation of methodological foundations for the construction of effective radio electronic systems for monitoring objects and scenes, in particular systems with partial active and passive microwave surveillance channels.

28. Development of methods of scanning television-optical microscopy for the study of micro-objects.

29. Development of methods of electronic optics and technology of electron beam devices.

29. Development of methods and means of defectoscopy of materials (railway rails).

30. Development of methods and means for measuring the parameters of magnetic and dielectric materials.

30. Development of methods of highly stable signal generation, in particular microwave.

31. Optimization and design of ultra-high frequency devices and antennas.

32. Improvement and development of methods of correlation signal processing.

33. Improvement and development of methods for measuring the phase shift of signals.

34. Modeling and study of field distribution in complex electrodynamic systems, including modulated nanoscale structures.

35. Analysis and synthesis of antenna devices based on new composite, including geotextile materials.

36. Development of methods and radioelectronic means for diagnosing the functional state of the human body.

37. Development of the theory and application of neural networks for signal analysis and system modeling.

38. Development of methods and models of new radioelectronic means of quantum medicine.

Scientific and pedagogical practice

Scientific practice involves the participation of a postgraduate student in: carrying out state-funded, contractual scientific research projects of structural units (laboratories) of the university, international and government projects, programs and grants, and other scientific events that correspond to the thematic focus of the postgraduate student's research work.

Pedagogical practice is a component of practical professional training for scientific and pedagogical activities in higher education institutions and is aimed at acquiring skills in conducting educational and developmental processes in a higher education institution and developing teaching skills, including teaching specialized disciplines that correspond to the thematic focus of the postgraduate student's research work, organizing educational activities for students, and engaging in relevant scientific and methodological work.

III. POSTGRADUATE STUDENT CERTIFICATION

The certification of applicants for the degree of Doctor of Philosophy is carried out on the basis of a public defense of scientific achievements in the form of a dissertation by a one-time specialized academic council established by Lviv Polytechnic National University.

A prerequisite for admission to the defense is the successful completion of the graduate student's individual study plan.

The minimum volume of the main part of the dissertation for this educational and scientific program is set within 3.25-4 author's sheets.