MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

LVIV POLYTECHNIC NATIONAL UNIVERSITY

APPROVED BY
Rector of Lviv Polytechnic
National University
_____ /Bobalo Yu.Ya./
«_____» _____ 2021

EDUCATIONAL AND SCIENTIFIC PROGRAM

third (educational and scientific) level of higher education

in specialty 105 "Applied physics and nanomaterials"

fields of knowledge 10 "Natural sciences"

Qualification: Doctor of Philosophy in specialty

"Applied physics and nanomaterials

Considered and approved
at a meeting of the Academic Council
Lviv Polytechnic National University
by «___» _____ 2021
Protocol №____

Lviv 2021

It was developed by the working group for ensuring the quality of the educational and scientific program, according to which the training of applicants at the third (educational and scientific) level of higher education in the specialty 105 "Applied physics and nanomaterials" is carried out as part of:

Project Team Leader **Guarantor of the educational-professional program:**	
Lukiyanets B.A.	- Ph.D.-M.Sc., Prof., Professor of the Department of Applied Physics and Nanomaterials Science
Members:	
Andrushchak A.S.	- Ph.D., Prof., Head of the Department of Applied Physics and Nanomaterials Science
Ilchuk H.A.	- Ph.D.-M.Sc., Prof., Professor of the Department of General Physics
Bryk T.M.	- Ph.D., Prof., Deputy director for scientific work of the IFKS of the National Academy of Sciences of Ukraine
Zachek I.R.	- Ph.D.-M.Sc., prof., professor of the Department of General Physics
Ivashchyshyn F.O.	- Ph.D., Ghief Researcher of the research laboratory of nanophysics and molecular energy
Malyk O.P.	- Ph.D.-M.Sc., Assoc. Department of Semiconductor Electronics
Zaichenko O.S.	- Ph.D., Associate Professor, Professor of the Department of Applied Physics and Nanomaterials Science
Vasyleshko L.O.	- Ph.D., Prof., Professor of the Department of Semiconductor Electronics
Matulka D.V.	- Ph.D., Associate Professor of the Department of Applied Physics and Nanomaterials Science
Korneev O.D.	- 1st-year graduate student of specialty 105 "Applied Physics and Nanomaterials"
Balaban O.V.	- Ph.D., Associate Professor of the Department of Applied Physics and Nanomaterials Science, The Head of the Scientific Society of Students, Postgraduates, Doctoral students and Young Scientists of the Institute of Applied Mathematics and Fundamental Sciences
Lykhodid K.S.	- Head of the Collegium and Professional Bureau of Students of the Educational and Scientific Institute of Applied Mathematics and Fundamental Sciences

Head of the working group (guarantor), Ph.D., prof. B.A. Lukiyanets

APPROVED AND PROVIDED
By order of the rector Lviv Polytechnic National University
from «_____» _____ 2021 № _____

LETTER OF AGREEMENT
educational and scientific program

Level of higher education	Third (educational and scientific)
Field of knowledge	10 Natural sciences
Specialty 105	Applied Physics and Nanomaterials
Qualification	Doctor of Philosophy

APPROVED

Scientific and methodical commission of specialty 105 Applied physics and nanomaterials
Protocol No._____
from "__" _____ 2021

Head of the NMC of the specialty
105 Applied physics and nanomaterials
_____

Director of the Institute of Applied Mathematics and Fundamental Sciences
_____ P.Ya. Pukach
"__" _____ 2021

AGREED

Head of the educational and methodical department

_____ Sviridov V.M.
"__" _____ 2021

Vice-rector for scientific work
_____ Demidov I.V.
"__" _____ 2021

Vice-rector for scientific and pedagogical work

_____ Davydchak O.R.
"__" _____ 2021

RECOMMENDED

Scientific and methodological council of the university

Protocol No._____

from "__" _____ 2021

_____ Zahorodnyj A.H

I. EDUCATIONAL COMPONENT OF THE EDUCATIONAL AND SCIENTIFIC PROGRAM

1. Profile of the Doctor of Philosophy program in specialty 105 "Applied physics and nanomaterials"

1 – General information	
1	**2**
Full name of the higher education institution and structural division	**Lviv Polytechnic National University**
The full title of the qualification in the original language	**Doctor of Philosophy in Natural Sciences by Specialty of Applied Physics and Nanomaterials**
The official name of the educational and scientific program	Applied Physics and Nanomaterials
Type of diploma and scope of the educational program	Diploma of Doctor of Philosophy, single, 43 ECTS credits of the educational component of the educational and scientific program, the term of the educational component of the educational and scientific program is 2 years
Cycle/level	National Qualification Framework – level 8, FQ-EHEA – third cycle, EQF-LLL – level 8
Prerequisites	Level of higher education "Master"
Language of instruction	Ukrainian
Basic concepts and their definitions	The educational and scientific program uses basic concepts and their definitions in accordance with the Law of Ukraine "On Higher Education" dated 07/01/2014 No. 1556-VII as amended, the Law of Ukraine "On Education" dated 09/05/2017 No. 2145- VIII, as amended, of the Law of Ukraine "On Scientific and Scientific-Technical Activity" dated November 26, 2015, No. 848-VIII, as amended, of the Procedure for Training Candidates for Higher Education Degrees of Doctor of Philosophy and Doctor of Science in Higher Education Institutions (Scientific Institutions), approved by Resolution of the Cabinet of Ministers of Ukraine dated 03/23/2016 No. 261 with changes and additions, the Procedure for conducting an experiment on awarding the degree of Doctor of Philosophy, approved by Resolution of the Cabinet of Ministers of Ukraine dated 03/06/2019 No. 167, Methodological recommendations for the development of higher education standards, approved by the Order of the Ministry of Education and Science of Ukraine dated 01.06.2017 No. 600 with changes and additions, Provisions on accreditation of educational programs, Subject area (field of knowledge, specialty)to which training is carried out higher education applicants, approved by order of the Ministry of Education and Science of Ukraine dated July 11, 2019 No. 977
2 – The purpose of the educational and scientific program	
	To deepen theoretical knowledge and practical abilities and skills in the field of natural sciences in the specialty "Applied physics and nanomaterials", to develop philosophical and linguistic competences, to form universal skills of a researcher, sufficient for conducting and successfully completing scientific research and further professional and scientific activities
3 - Characteristics of the educational and scientific program	
Subject area (field of knowledge, specialty)	Field of knowledge 10 Natural sciences, specialty 105 Applied physics and nanomaterials
Orientation of the educational and scientific program	The educational and scientific program is based on the fundamental postulates of applied physics and the results of modern scientific research in the field of nanotechnology. The program is aimed at acquiring the necessary research skills for a scientific career, teaching special disciplines in the field of solid-state physics, optoelectronics, nanoengineering of materials and nanotechnologies, as well as commercialization of the results of research activities and technology transfer, and provides a basis for conducting scientific research and further professional and

	scientific activity

1	2
Features of the program	The educational and scientific program covers a wide range of modern innovative vectors for the development of the theory and practice of applied physics and nanomaterials, which forms an updated theoretical and applied basis for conducting scientific research.
4 – Eligibility of graduates of the educational program to employment and further education	
Suitability for employment	Jobs in public and private higher education institutions, scientific and research institutions as teachers and researchers, in enterprises and organizations of various types of activities and forms of ownership in managerial positions.
Further education	Completion of the scientific program of the fourth (scientific) level of higher education to obtain the degree of Doctor of Science.
5 – Teaching and assessment	
Teaching and learning	A combination of lecture, laboratory and practical classes, a pedagogical workshop, consulting with a scientific supervisor, a scientific and pedagogical community with independent scientific and educational work.
Assessment	Exams, assessments, current control.
6 – Software competencies	
Integral competence (InC)	The ability to produce innovative scientific ideas, to master the methodology of scientific and pedagogical activity, to solve complex problems in the process of innovative research and professional activity, to conduct original scientific research at the international and national level.
General competences (GC)	1. In-depth knowledge of modern research methods in the field of applied physics and nanomaterials and in related fields. 2. Critical analysis, assessment and synthesis of new ideas. 3. The ability to effectively communicate with the wider scientific community and the public on topical issues of applied physics and nanomaterials science. 4. Social responsibility for the results of strategic decision-making; 5. Initiation of original research and innovation complex projects. 6. Leadership and the ability to work both autonomously and in a team during project implementation.
Special (professional) competences (FC)	1. Knowledge of modern development trends and the most important new scientific achievements in the field of applied physics and nanomaterials, as well as related scientific areas. 2. Systematic knowledge and understanding of modern scientific theories and innovative technologies in the field of nanomaterials science with the aim of their effective use in solving applied physics problems. 3. The ability to effectively apply methods of analysis, mathematical modeling, perform physical and mathematical experiments when conducting scientific research. 4. The ability to integrate knowledge from other disciplines, apply a systematic approach and take into account non-technical aspects when solving engineering problems and conducting research. 5. The ability to develop and implement projects, including own research, which provide an opportunity to rethink existing or create new knowledge. 6. The ability to argue the choice of a method of solving a specialized problem, critically evaluate the obtained results and defend the decisions made.
7 – Program learning outcomes	
Knowledge (Kn)	1. The ability to demonstrate systematic knowledge of modern research methods in the field of applied physics and nanomaterials.

1	2
Knowledge (Kn)	2. The ability to demonstrate in-depth knowledge in the chosen field of scientific research. 3. The ability to demonstrate an understanding of the impact of technical solutions in a public, economic and social context.
Competency (C)	1. Search, analyze and critically evaluate information from various sources. 2. Apply knowledge and understanding to solve problems of synthesis and analysis of elements and systems characteristic of the chosen field of scientific research. 3. Investigate and model phenomena and processes of various complexity when solving problems of nanomaterials science. 4. Apply a systematic approach, integrating knowledge from other disciplines and taking into account non-technical aspects, when solving theoretical and applied problems of the chosen field of scientific research. 5. Combine theory and practice, as well as make decisions and develop a strategy for solving scientific and applied problems, taking into account universal human values, public, state and industrial interests. 6. Work effectively both individually and as part of a team. 7. With the use of the acquired research skills, the ability to independently successfully conduct experimental research. 8. Assess the expediency and possibility of applying new methods and technologies in the problems of synthesis of nanomaterials and solving problems of applied physics. 9. Argue the choice of methods for solving a scientific and applied problem, critically evaluate the obtained results and defend the decisions made.
Communication (COM)	1. The ability to communicate effectively on a professional and social level. 2. The ability to present and discuss the obtained results and transfer the acquired knowledge.
Autonomy and responsibility (AaR)	1. The ability to independently conduct scientific research and make decisions. 2. The ability to constantly study in order to deepen the acquired and acquire new professional knowledge. 3. The ability to take responsibility for the work performed and achieve the set goal in compliance with the requirements of professional ethics.
8 – Resource support for the implementation of the educational program	
The main characteristics of staffing	100 percent of scientific and pedagogical workers involved in teaching a cycle of disciplines that provide special (professional) competencies of a graduate student have scientific degrees and academic titles.
The main characteristics of material and technical providing	Use of modern equipment for technological and scientific research of leading companies, in particular "ECO Chemia" (Netherlands), "Avantes" (Netherlands), "Renishaw" (England).
The main characteristics of informational and methodical support	Using the virtual learning environment of the Lviv Polytechnic National University and the Higher Education Institution of Ukraine.
9 – Academic mobility	
National Credit Mobility	Based on bilateral agreements between Lviv Polytechnic National University and universities of Ukraine.
International Credit Mobility	Within the framework of the EU Erasmus+ program on the basis of bilateral agreements between Lviv Polytechnic National University and educational institutions of partner countries.
Teaching of foreign applicants for higher education	is possible

2. Distribution of content of Educational-scientific program of the PhD Doctor's degree in specialty 105 «Applied Physics and Nanomaterials» according to groups of components and preparation cycles

№ s/n	Preparation cycle	The amount of learning capacity of the applicant of higher education (credits / %)		
		Mandatory components of educational-scientific program	Selective components of educational-scientific program	In total for the whole period of study
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.	Cycle of subjects of free choice of a graduate student	-	3/7	3/7
Total for the entire period of study		31/72	12/28	43/100

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

Code	Components of the educational component	Number of credits	Form summary control
1	2	3	4
1. **Mandatory components of the educational component**			
1.1. Cycle of disciplines that form general scientific competences and universal skills of the researcher			
SK1.1.	Philosophy and Methodology of Science	3	exam
SK1.2.	English Language For Academic Purposes, part 1	4	credit
SK1.3.	English Language For Academic Purposes, part 2	4	exam
SK1.4.	Professional Pedagogy	3	exam
SK1.5.	Academic Entrepreneurship	4	credit
SK1.6.	Teaching Practice	3	credit
In total for a cycle:		**21**	
*1.2. Cycle of disciplines forming professional competences**			
SK2.1.	Analytical and Numerical Methods of Research	4	exam
SK2.2.	Research Seminar in Applied Physics and Nanomaterials Science	3	credit
SK2.3.	Research Methods in Applied Physics and Nanomaterials Science	3	credit
In total for a cycle:		**10**	
2. **Elective components of the educational component****			
2.1. Cycle of disciplines that form general scientific competences and universal skills of the researcher			
B1.1	Business Foreign Language	3	test

B1.2	Psychology of Creativity and Invention	3	credit
B1.3	Management of Scientific Projects	3	credit
B1.4	Technology of Processing Grant Applications and Patents	3	credit
B1.5	Rhetoric	3	credit
B1.6	Modern Inventical Management in Scientific and Research Activities	3	credit
B1.7	Open Science Practices	3	credit
B1.8	Academic Integrity and Education Quality	3	credit
B1.9	Methodology of Scientific Paper Publishing	3	credit
B1.10	Quality of Higher Education (Internal Quality Assurance Systems)	3	credit
In total for a cycle:		**3**	
2.2. Cycle of disciplines forming professional competences			
B2.1.	Spatial Anisotropy of Iinduced Optical Effects in Crystalline Materials	3	exam
B2.2.	Physics of Condenced State and Quantum-Dimensional Systems	3	exam
B2.3.	Physics of Supramolecular Structures and Devices	3	exam
B2.4.	Modern Methods of Physical Research	3	exam
B2.5.	Physical Processes Simulation	3	exam
ВБ2.6.	Specific Areas of Chemistry	3	exam
B2.7.	Selected Sections and Technology of Semiconductors and Dielectrics	3	exam
B2.8.	Technology and Physics of Electronics and Spintronics Nanostructures	3	exam
B2.9.	Spectroscopic Methods of Materials Research	3	exam
In total for a cycle:		**6**	
3. Disciplines of the graduate student's free choice ***			
B3.1	Discipline of the graduate student's free choice	3	credit
Total per cycle:		**3**	
TOGETHER		**43**	

Note: * - a list of disciplines that form professional competences, offered jointly for the ONPs of related fields and specialties;

** - the list of optional disciplines forming professional competences must contain eight disciplines, from which the graduate student chooses two;

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

Tentative proposal for combining specialties and fields for teaching disciplines that form professional competences (OK1 and OK2)

Code and name of specialty	Institute
105 Applied physics and nanomaterials	IMFS
153 Micro- and nanosystem technology	ITRE

4. Matrix of correspondence of program competences educational components

Disciplines / Competences	SK1.1.	SK1.2.	SK1.3.	SK1.4.	SK1.5.	SK1.6.	SK2.1.	SK2.2.	SK2.3.	B1.1.	B1.2.	B1.3.	B1.4.	B1.5.	B1.6.	B1.7.	B1.8.	B1.9.	B1.10.	B2.1.	B2.2.	B2.3.	B2.4.	B2.5.	B2.6.	B2.7.	B2.8.	B2.9.
INT	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
GC1	•						•		•															•				
GC2	•				•						•									•	•	•			•	•	•	
GC3		•	•		•	•				•		•		•		•	•											
GC5	•	•	•		•					•	•			•	•			•	•									
GC6	•				•						•		•				•											•
GC7	•				•						•	•	•			•	•											
FC1									•											•	•	•		•				•
FC2							•	•												•	•	•	•	•	•	•	•	•
FC3							•		•											•			•	•		•	•	•
FC4							•														•		•	•	•	•	•	•
FC5									•											•	•	•	•	•	•	•	•	•
FC6	•								•											•	•	•	•	•	•	•	•	•

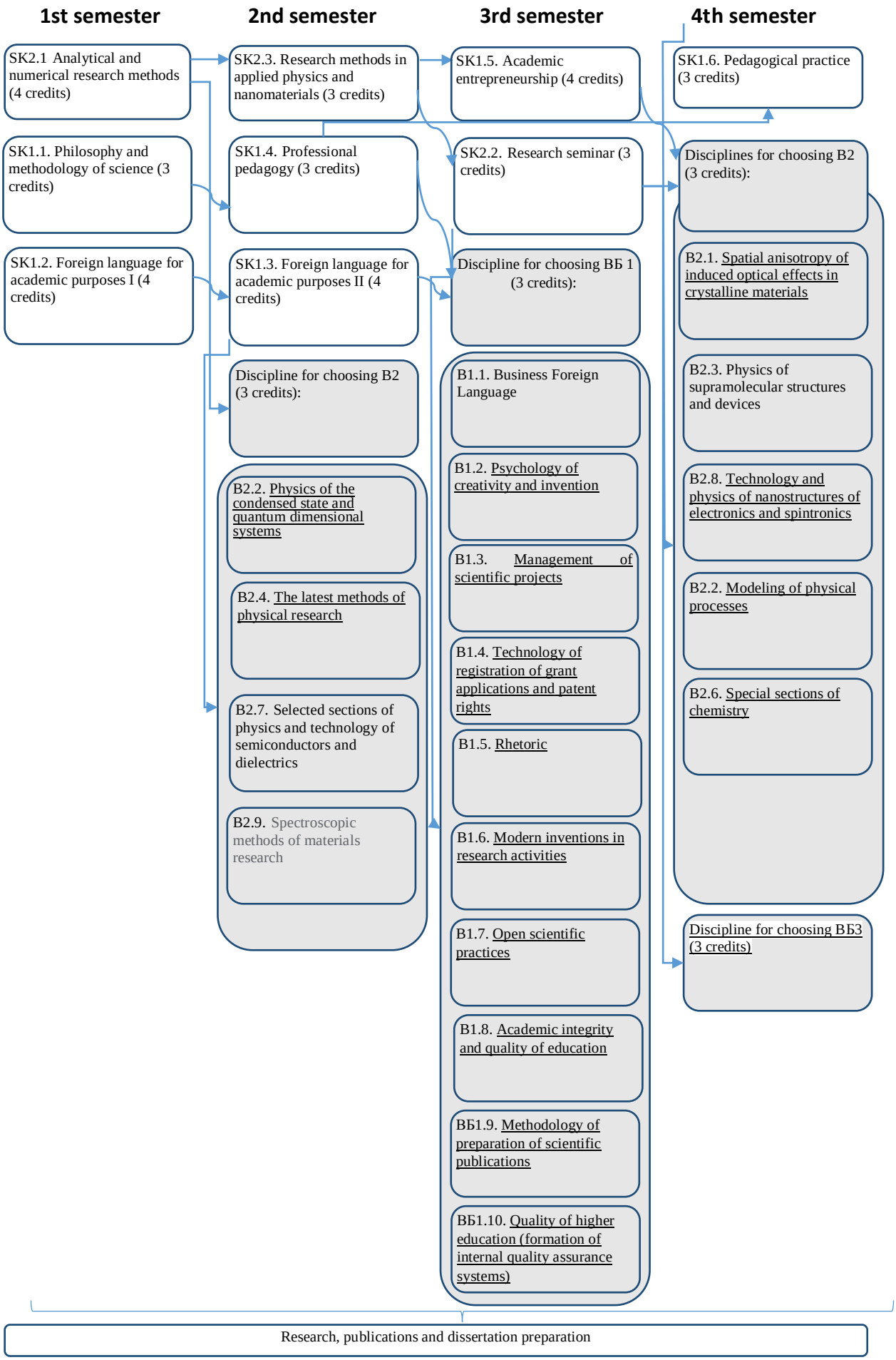
Conventional designations: SKi – compulsory discipline, Bi – selective discipline, i – discipline number in the list of components of the educational component, INT – integral competence, GCj – general competence, FCj – professional (special) competence, j – competence number in the list of competences educational component.

5. Matrix of compliance of program competences with the educational components of the PhD Doctor's program for the specialty 105 " Applied physics and nanomaterials "

Disciplines / The results teaching	SK1.1.	SK1.2.	SK1.3.	OK1.4.	SK1.5.	SK1.6.	SK2.1.	SK2.2.	SK2.3.	B1.1.	B1.2.	B1.3.	B1.4.	B1.5.	B1.6.	B1.7.	B1.8.	B1.9.	B1.10.	B2.1.	B2.2.	B2.3.	B2.4.	B2.5.	B2.6.	B2.7.	B2.8.	B2.9.
Kn1								•	•											•	•	•	•	•			•	•
Kn2							•		•			•								•	•	•			•	•		•
Kn 3		•	•				•					•									•					•	•	
C1					•	•	•					•				•	•				•				•	•	•	•
C2				•	•	•	•				•	•	•			•	•	•		•		•		•	•	•	•	•
C3		•	•		•	•				•				•	•				•	•		•		•	•	•	•	•
C4	•				•	•	•					•									•			•	•	•	•	•
C5	•				•	•	•					•				•	•				•			•	•	•	•	•
C6					•	•	•		•			•				•	•							•	•	•	•	•
C7	•			•	•	•	•	•			•	•	•			•	•	•				•	•	•	•	•	•	•
C8							•		•			•									•	•	•		•	•	•	•
C9		•	•		•	•				•				•	•	•			•	•		•		•				•
COM1		•	•		•	•			•	•				•	•	•			•									
COM2		•	•		•	•			•	•				•	•	•			•									
AiB1	•			•	•	•	•	•	•		•		•			•	•	•					•	•	•	•	•	•
AiB2	•					•			•		•					•												
AiB3	•			•		•					•					•									•	•	•	

Conventional designations: SKi – mandatory discipline, Bi – selective discipline, i – number of the discipline in the list of components of the educational component, Knm – program results (knowledge), Cm – program results (skills), m – number of the program result in the list of program results educational component.

6. Structural and logical scheme of the educational component-ONP at the third (educational and scientific) level of doctors of philosophy in specialty 105 "Applied physics and nanomaterials"



II. The scientific component of the educational and scientific program

The dissertation for obtaining the degree of Doctor of Philosophy is an independent comprehensive study that offers a solution to an actual scientific and applied task in the specialty 105 Applied Physics and Nanomaterials, the results of which are characterized by scientific novelty and practical value and are published in relevant publications.

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

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

Topics of scientific research by specialty 105 "Applied physics and nanomaterials":

1. Creation technology and physical properties of heterophase structures formed on the basis of supramolecular ensembles of hierarchical architecture
2. Nanostructured materials for ultra-high capacity energy storage devices.
3. Obtaining and researching the physical properties of films of semiconductor compounds A2B6 with metal nanoparticles and structures based on them.
4. New multifunctional materials based on complex oxides of rare earth and transition elements: synthesis, structure and phase transformations.
5. Increasing the efficiency of electric, piezo, acoustic and nonlinear optical interactions in crystalline materials.
6. Technology of creation and research of crystalline nanocomposites and their practical use.
7. Kinetic properties of semiconductor nanostructures.
8. Synthesis and properties of nanostructured biocarbon materials.
9. Development of electrochemical systems with Faraday and non-Faraday charge accumulation.

III. Certification of graduate students.

Attestation of applicants for higher education with the degree of doctor of philosophy is carried out by a specialized scientific council, permanently active or formed for a one-time defense, on the basis of a public defense of scientific achievements in the form of a dissertation.

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

The volume of the main text of the dissertation should be 4.0 - 5.5 pages.

Candidates of higher education for the degree of Doctor of Philosophy defend their dissertations, as a rule, in a permanent specialized academic council for the relevant specialty, which functions in the higher educational institution where the graduate student was trained. The academic council of a higher educational institution has the right to submit documents to the National Agency for Quality Assurance of Higher Education for the accreditation of a specialized academic council formed for a one-time defense, or to apply to another higher educational institution where a permanent specialized academic council in the relevant specialty operates .

The condition of attestation of higher education holders of the degree of Doctor of Philosophy is compliance with the principles of academic integrity, taking into account the norms "Regulations on Academic Integrity at the National University "Lviv Polytechnic".