National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Department of General Physics

Optics. Quantum physics

Working program of basic discipline (Silabus)

Requisites for basic discipline	
Level of higher education	***First (bachelor's)***
Branch of knowledge	*10 Natural sciences*
Specialty	*163 Biomedical Engineering*
Educational program	*Biomedical Informatics*
Discipline status	*Normative*
Form of study	*full-time*
Year of preparation, semester	*2 course, autumn semester*
The scope of discipline	*90 hours / 3 credits ECTS*
Semester control / Control measures	*Exam/ Test Work, Modular Test Work*
Lessons schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about course leader / teachers	***Lecturer:*** *Ph.D., Khist V.V., khist2012@gmail.com* ***Practical:*** *Ph.D., Khist V.V.*
Course placement	*Platform «Sikorsky»*

Distribution of hours

Semester	Lectures	Practical	Laboratory	Independent Work	Semester attestation
autumn semester	*20*	*18*	*16*	*36*	*Exam*

Curriculum of the discipline

1. Description of the discipline, its purpose, subject of study and learning outcomes

The purpose of the discipline *is to form students' competencies, skills and knowledge in the field of physics in relation to the fundamental concepts, laws and theories of classical and modern physics, which provides them with effective mastery of special disciplines and further use of new physical principles in information technology and computer sciences.*

The subject of the discipline *- laws, methods and means of mechanics, electricity and magnetism, optics, physics of quantum phenomena, as well as atomic physics as components of the process of physical research.*

According to the requirements of the educational-professional program, students after mastering the discipline must demonstrate the following results:

CAPABILITIES

General competencies *(OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

GC 1 *- Ability to abstract thinking, analysis and synthesis.*
GC 2 *- Ability to search, process and analyze information from various sources.*

GC 3 *- Ability to identify, formulate and solve problems.*
GC 5 *- Ability to work in an international context.*

Special (professional) competencies *(OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

PC 1 *- Ability to solve complex problems of biomedical engineering using the methods of mathematics, natural and engineering sciences.*
PC 2 - *Ability to develop a working hypothesis, plan and set experiments to test the hypothesis and achieve the engineering goal using appropriate technologies, technical means and tools.*
PC 9 *- Ability to create tools and methodologies of scientific activity, evaluation and implementation of the results of modern developments, solutions and achievements of engineering and exact sciences in medicine and biology.*

The program learning outcomes after studying the discipline "Optics. Quantum physics " are *(OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

PLO 1 *- Know, understand and be able to apply at the basic level the basic principles of general and theoretical physics, in particular, classical, relativistic and quantum mechanics, molecular physics and thermodynamics, electromagnetism, wave and quantum optics, atomic physics and atomic nucleus to establish, analyze, interpretation, explanation and classification of the essence and mechanisms of various physical phenomena and processes for solving complex specialized problems and practical problems in physics and / or astronomy.*

PLO 7 *- Know the basic skills of theoretical and / or experimental research in certain special sections of physics or astronomy, performed individually (autonomously) and / or as part of a scientific group.*

PLO 9 - *Be able to apply basic mathematical knowledge used in physics and astronomy: analytical geometry, linear algebra, mathematical analysis, differential and integral equations, probability theory and mathematical statistics, group theory, methods of mathematical physics, theory of functions of complex variables, mathematical modeling.*

PLO 10 *- Be able to plan research, choose the best methods and means to achieve the goal of research, find ways to solve scientific problems and improve applied methods.*

PLO 11 *- Be able to organize, interpret and summarize the obtained scientific and practical results, draw conclusions.*

PLO 16 *- Be able to study independently and improve their skills.*

PLO 25 *- Be able to conduct theoretical or experimental research performed individually or as part of a research group.*

1. Prerequisites and post requisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

The value of the discipline in the training of specialists:

The course of general physics, together with the courses of higher mathematics and computer science, plays the role of a fundamental physical and mathematical base, without which the successful activity of a specialist in any field of technology is impossible. This program reflects the current state of teaching physics in higher technical educational institutions. It involves a natural combination of

macroscopic and microscopic approaches and the disclosure of internal logical connections between different branches of physical science.

In the structural and logical scheme of the specialist-training program, the following disciplines and credit modules provide the credit module:

Name of credit module (discipline)	*Topics from RNP (names and numbers) or code for OPP, Providing a credit module.*	
1 / I Mathematical analysis	*Differential calculus of functions of one and several variables*	*MPN 2.01.01*
	Integral calculus of a function of one variable	*MPN 2.01.02*
	Multiple integrals	*MPN 2.01.05*
	Theory of function of a complex variable	*MPN 2.01.07*

The credit module in the structural and logical scheme of the training program provides the following disciplines and credit modules:

Name of credit module (discipline)
Theory of biomedical signals
Theory of automatic control

2. The content of the discipline

The main sections and topics that will be considered in the process of studying the course:

Section 1. "Optics. Quantum physics"

Partition 1. Wave Optics

Topic 4.1. Geometric optics. General concepts of wave optics.

Development of ideas about the nature of light. The basic laws of geometric optics and the limits of their application. The Farm Principle.

The possibility of the existence of an electromagnetic wave as a consequence of the application of the Maxwell equations. Wave processes, types of waves. Equations and characteristics of a flat monochromatic wave. Wavelengths and phase velocity. General properties of electromagnetic waves. Poynting vector, intensity of the electromagnetic wave.

Basic concepts and parameters of wave optics. The process of radiation of light and its connection with the basic properties of natural light. Generalization of dualistic notions about the nature of light.

Topic 4.2. Interference.

The notion of interference and coherence. Basic parameters of interference schemes. Intensity at interference.

Types of coherence. Obtaining coherent light beams, interference schemes. Interferometers. Influence of various factors on observation of interference.

Topic 4.3. Diffraction.

The diffusion of waves, the Huygens-Fresnel principle. Fraunhofer diffraction on one slit.

Fraunhofer diffraction on a one-dimensional lattice. X-ray diffraction on crystals, Wolf-Bragg's formula. Fresnel diffraction.

Topic 4.4. Polarization

Polarized and natural light, types of polarization. Malus's law. Polarization of light at reflection from dielectric.

Polarization of light with birefringence. Natural rotation of the plane of polarization and the effect of Faraday.

Topic 4.5. Dispersion, absorption and diffusion of light

The concept of the dispersion of waves. An Elementary Electronic Theory of Light Dispersion. The concept of a wave packet and group velocity.

Section 2. Atomic physics.

Topic 5.1. Elements of quantum optics.

5.1.1. Thermal radiation.

Thermal radiation and luminescence. Characteristics of thermal radiation. The law of Stefan-Boltzmann, the law of the displacement of Wien, Kirchhoff's law. Dependence of the absorption and radiative power on the frequency. The formula of Rayleigh-Jeans, ultraviolet disaster, the limitations of classical physics. Quantum hypothesis, Planck's formula.

5.1.2. External photoelectric effect. X-ray braking radiation. Compton's effect

Photons, energy, mass and momentum of a photon. Photo effect Regularities and elementary quantum theory of the external photoelectric effect, Einstein's formula for the photoelectric effect. Brakes are not X-rays. Short-wave limit of the braking spectrum. Compton's Effect and Its Elementary Theory. Interaction of photons with matter.

Topic 5.2 The structure of the atom

5.2.1. Models of the structure of the atom. Experimental confirmation of the discreteness of emission and absorption spectra of atoms.

Basic hypotheses about the structure of the atom. Experience Rutherford. Patterns of the emission spectra of atoms.

Bout's postulates. Bora quantization rule. The radius and energy of the Bohr stationary orbits. Hydrogen-like systems. Disadvantages of Bohr's theory. The success of Franco-Hertz.

Topic 5.3. Elements of quantum physics

5.3.1. Wave properties of microparticles. Experimental confirmation of de Broglie hypothesis .. Heisenberg uncertainty relation

De Broglie hypothesis. Experimental investigation of microparticle diffraction. The principle of uncertainty, the Heisenberg ratio. Estimated calculations using Heisenberg's relations. The boundaries of the classical way of describing.

5.3.2. Schrödinger equation

Wave function, its probabilistic content and properties. Schroedinger's time and stationary equation. Operator method for recording Schrödinger equations. The classical problems of quantum mechanics: a particle in a one-, two-, three-dimensional potential well. Passage of a particle through a potential barrier (tunneling effect).

3. Training materials and resources

Basic literature:

1. Kucheruk I.M., Gorbachuk I.I. General course of physics. Optics. Quantum physics. - K: Technica, 1999.
2. Saveliev I.V. The course of general physics, vols. 1-3. -M. : Nauka, 1982.
3. Irodov I. E. Problems in general physics. – M.: Nauka, 1987 or SPb .: Lan' 2001.
4. Methodical instructions to the laboratory practice in physics (optics). Briginets V.P., Grib B.N., Guseva O.A. and others. - K: KPI, 1989.
5. General Physics. Quantum physics: guidelines for the implementation of laboratory ro-bits for full-

time students of the faculty of computer science and computer science. V.P. Briginets, O.O.Guseva, I.V. Linchevsky, N.O. Yakunina. - K.: NTUU "KPI", 2009.-60 p.

Additional literature:

6. Sivukhin DV The general course of physics. - M.: Nauka, 1977 - 1986, vol. 4.
7. Sivukhin DV The general course of physics. - M.: Nauka, 1977 - 1986, vol. 5.
8. Matveev AN Optic. - M .: Vyschaya Shkola, 1986.
9. Matveev AN Atom physics. - M .: Vyschaya Shkola, 1983.
10. Irodov I.E. Wave processes. - M: Laboratory of Basic Knowledge, 2000.
11. Irodov I.E. The quantum physics. - M: Laboratory of Basic Knowledge, 2002.
12. Berkeley Physics Course. - M: Nauka, 1975 - 1977, Vol. 2
13. Feynman R., Leighton R., Sands. Feynman lectures on physics. - M: Mir, 1977.
14. Firgant E.V. Guide to solving problems in the course of general physics.
15. Belikov B. S. Solution of problems in physics. - M .: Vyschaya Shkola, 1986.
16. Quantum physics. Methodical instructions to laboratory work from physics. K .: NTUU "KPI", 2006. - 12 p.

Educational content

4. Methods of mastering the discipline (educational component)

The educational part of the discipline consists of lecture material, practical and laboratory classes and control activities. When teaching the course, it is recommended to build students' familiarity with the subject so that they not only receive information about the course being studied, but also feel the connection between different topics of the credit module, as well as the place of the module among other physical disciplines. The general methodological approach to teaching the discipline is defined as communicative-cognitive and professional-oriented, according to which the center of the educational process is the student - the subject of study and the future specialist.

Lections

Lection № 1	***Geometric optics and general concepts of electromagnetic waves***
	Development of ideas about the nature of light. Basic laws of geometric optics and limits of their application. Fermat principle
Literature	[1]1.1 - 1.4; [2] 104, 105, 110, 115, 118 [1] 3.1 [2] 119
Lection № 2	***General concepts of electromagnetic waves***
	The possibility of the existence of an electromagnetic wave because of the application of Maxwell's equations. Wave processes, types of waves. Equations and characteristics of a plane monochromatic wave. Wave surfaces and phase velocity. General properties of electromagnetic waves. Pointing vector, electromagnetic wave intensity.
Literature	*[1] 3.1;* *[2] 119*
Lection № 3	***Two-beam interference of light***
	The concept of interference and coherence. The main parameters

	are three interference schemes. Intensity in interference
Literature	*[1] 3.2 - 3.4, 3.6;* *[2] 120-123*
Lection № 4	***Methods of observing light interference***
	Types of coherence. Obtaining coherent light beams, interference schemes. Interferometers. Influence of various factors on the observation of interference
Literature	*[1] 3.2 - 3.4, 3.6;* *[2] 120- 123*
Lection № 5	***Diffraction of light***
	Wave diffraction, Huygens - Fresnel principle. Fraunhofer diffraction in one slit
Literature	*[1] 4.1, 4.3;* *[2] 125, 126, 129*
Lection № 6	***Diffraction on the optical lattice and on the crystals. Fresnel diffraction***
	Fraunofer diffraction on a one-dimensional lattice. X-ray diffraction on crystals, Wolf-Bragg formula. Fresnel diffraction
Literature	*[1] 4.2, 4.4;* *[2] 127, 128, 130, 131*
Lection № 7	***Polarization of light. The behavior of light in uniaxial crystals and other anisotropic media. Dispersion of light***
	Polarized and natural light, types of polarization. Malus's law. Polarization of light during reflection from a dielectric. *The concept of wave dispersion. Elementary electronic theory of light dispersion.*
Literature	*[1] 5.1, 5.4-5.6;* *[2] 134, 135* *[1] 6.1-6.3, 6.5;* *[2] 142-146*
Lection № 8	***Photo effect and X-ray braking radiation***
	Photons, energy, mass and momentum of a photon. Photo effect. Regularities and elementary quantum theory of external photo effect, Einstein's formula for photo effect. Inhibitory X-ray radiation.
Literature	*[1], 9.1, 9.2, 9.4, 10.1, 10.2, 10.3;* *[3], 8, 9, 11*
Lection № 9	***Atom structure models and experimental facts. Bohr's postulates***
	Basic hypotheses about the structure of the atom. Rutherford's experiment. Regularities of the emission spectra of atoms. *Bohr's postulates. Bohr quantization rule.*
Literature	*[1], 13.1, 13.2;* *[3], 12-14*

Lection № 10	***Wave properties of particles of matter. The principle of uncertainty***
	De Broglie's hypothesis. Experimental studies of micro particle diffraction. The principle of uncertainty, the Heisenberg ratio.
Literature	*[1] 12.1, 12.2;* *[3] 18–20.*

Practical classes

The main goals of the cycle of practical classes:
- consolidation of the assimilation of the content of the lecture material;
- assimilation of methods of analysis of physical phenomena;
- development of the ability to calculate physical quantities by analytical expressions;
- development of the ability to use mathematical apparatus for solving certain physical

№ 1	***Geometric optics. General concepts of wave optics***
	Laws of reflection and refraction of light. The course of rays through a plane-parallel plate and a triangular prism. Full internal reflection, limit angle
Literature	*№№ 5.16, 5.18, 5.20*
Tasks on the IWS	*№№ 5.17, 5.22*
№ 2	***Interference***
	Interference of light, conditions of maxima and minima. Interference in thin films.
Literature	*№№ 5.73, 5.80, 5.81, 5.96*
Tasks on the IWS	*№№ 5.82, 5.85*
№ 3	***Diffraction***
	Fraunhofer diffraction on a slit and a one-dimensional flat lattice
Literature	*№№ 5.125, 5.126, 5.129*
Tasks on the IWS	*№№ 5.182, 5.191, 5.201*
№ 4	***Polarization***
	Polarization of light. Malus's law.
Literature	*№№ 5.171, 5.174, 5.176*
Tasks on the IWS	*№№ 5.182, 5.191*
№ 5	***Thermal radiation***
	Application of the laws of thermal radiation
Literature	*№№ 5.263, 5.264*
Tasks on the IWS	*№№ 5.265, 5.273*
№ 6	***Photo effect***
	External photo effect. X-ray braking radiation, shortwave limit.
Literature	*№№ 5.290, 5.292*
Tasks on the IWS	*№№ 5.288, 5.293*
№ 7	***Models of atomic structure***
	Bohr atom model
Literature	*№№ 6.25, 6.22*
Tasks on the IWS	*№№ 6.38, 6.39*
№ 8	***Wave properties of microparticles***
	Experimental confirmation of de Broglie's hypothesis
Literature	*№№ 6.50, 6.68*
Tasks on the IWS	*№№ 6.57, 6.59*

№ 9	Final lesson

Laboratory works

The main tasks of the cycle of laboratory works:
The main tasks of laboratory lessons from this credit module:
- consolidation of the assimilation of the content of the lecture material;
- assimilation of methods of analysis of physical phenomena;
- development of the ability to experiment with physical phenomena;
- development of the ability to calculate physical quantities by analytical expressions;
- Development of the ability to apply a mathematical device for the study of certain physical phenomena.

№	Name of laboratory work	Number of hours
1	Measurement of light interference (Fresnel bi-prism)	**4**
2	Study of Fraunhofer diffraction in the slit	**2**
3	Study of polarized light	**4**
4	Study of the laws of thermal radiation. Study of the optical spectrum of atomic hydrogen	**2**
5	Study of the Peltier effect in semiconductors and the Ramsauer effect	**2**
6	**Colloquium of laboratory lessons**	**2**

5. Independent student work

The student's independent work is the main means of mastering the study material in his free time and includes:

№	Type of independent work	Number hours
1	Preparation for classroom classes	18
2	Preparation for modular control work	3
3	Exam preparation	15
	Total	36

Policy and control

6. Policy of academic discipline (educational component)

Attending classes

Attendance at lectures is optional. Attending practical classes is desirable, as they are used to write express tests / tests, as well as to defend practical work.

The grading system is focused on obtaining points for student activity, as well as performing tasks that are able to develop practical skills and abilities.

Control measures missed

Missed control measures (defense of practical work) must be practiced in the next classes, if the task is scheduled for the current lesson, or in consultations.

Omissions of writing a module test and express test are not fulfilled.

Calculation and graphic work, which is submitted for inspection in violation of the deadline, is evaluated with a decrease in the number of weight points.

Violation of deadlines and incentive points

Encouragement points		Penalty points *	
Criterion	Weight points	Criterion	Weight points
Improving practical work	1 points (for each practical work)	Untimely implementation and test of practical work	From -0.5 points to -5 points (depending on the delivery date)
Passing distance courses on topics that are agreed with teachers	5 points	Untimely execution and test of calculation and graphic work	From -2 points to -20 points (depending on the construction period)
Registration of scientific work for participation in the competition of student scientific works	10 points		
Writing abstracts, articles, participation in international, national and / or other events or competitions on the subject of the discipline	5 points		

** if the control measure was missed for a good reason (illness, which is confirmed by a certificate of the established sample) - penalty points are not accrued.*

Academic integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Norms of ethical behavior

Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Procedure for appealing the results of control measures

Students have the opportunity to raise any issue related to the control procedure and expect it to be addressed according to predefined procedures.

The student has the right to appeal the results of the control measure according to the approved provision on appeals in the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (approved by the order №NON/128/2021 from 20.05.2021) - https://osvita.kpi.ua/index.php/node/182

Inclusive education

The discipline «Optics. Quantum physics" can be taught to most students with special educational needs, except for students with severe visual impairments who do not allow to perform tasks using personal computers, laptops and / or other technical means.

Distance learning

Distance learning takes place through the Sikorsky Distance learning Platform «Sikorsky».

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.

The teacher offers the list of courses after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express control / test tasks, practical work).

Performance of practical works, and performance of settlement and graphic work, is carried out during independent work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).

Learning a foreign language

Teaching in English is carried out only for foreign students.

At the request of students, it is allowed to study the material with the help of English-language online courses on topics that correspond to the topics of specific classes.

7. Monitor and evaluate the system of evaluation of learning outcomes (Rating System of Evaluation)

Types of control:
Current control: Modular Test Work, Final Test Work.

Calendar control: *conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.*

Semester control: *exam.*

Conditions of admission to the semester control: *successful completion of all control works, semester rating not less than 30 points.*

In the first lesson, students get acquainted with the rating system of assessment (RSA) of the discipline, which is based on the "Regulations on the system of assessment of learning outcomes", https://document.kpi.ua/files/2020_1-273.pdf.

Rating system for assessing learning outcomes

1. Profile competence in the study of physics of technical profile can be determined by three levels.

• A high level of profile competence is demonstrated by the ability to perform tasks that need to explain or predict phenomena based on their modeling, analyze the results of previous research, compare data, conduct scientific arguments to confirm their position, or evaluate different points of view.

• The average level of profile competence demonstrates the ability to use the acquired knowledge to explain or predict natural phenomena, to identify questions that could be answered by science, to provide information confirming the conclusions formulated by the task.

• Low level - tests the ability to update basic knowledge, facts, provide examples and use basic concepts to confirm the correctness of the already formulated conclusions.

Rating types of educational work

A student's rating in the RD discipline consists of the points he receives for:

1) Work in practical classes: n1 = 10

2) Performance and registration of n2 = 5 laboratory works, their defense at classes during the semester.

3) Execution of n3 = 1 modular control work.

4) Execution of n4 = 1 final test work

5) Answer the exam.

Rating points system and evaluation criteria

Laboratory workshop

Weight score for laboratory lesson r_{lc} = 5

0 points - no protocol of laboratory work failure to perform tests;

1-2 points - formal readiness for work, incomplete registration of the protocol, protection not at a high level (answers not to all questions, not enough complete answers, not understanding of the physical phenomena which are investigated in laboratory work), not performance of tests;

3-4 points - full design of the protocol (theoretical part, tables, calculations, graphs); defense of laboratory work at a high level (thorough answers to all questions), performance of tests for 60-70 points;

5 points - full design of the protocol (theoretical part, tables, calculations, graphs); protection of laboratory work at a high level (thorough answers to all questions)

The maximum total score for laboratory classes during the semester is:

$$n_1 * r_{lc} = 5*5 = 25$$

A student must complete all laboratory work curriculum.

Weight penalty point for untimely defense of laboratory work r = 2 points.

Work on practical classes: n_2 = 10

- Active creative work - 0.5 points;

- Fruitful work - 0.3 points;

- Passive work -0 points.

The maximum total score for practical classes during the semester is:

$$n_2 * r_{pc} = 10*0.5 = 5$$

Modular control (Modular Control Work)

Weight score for control work r_{mcw} = 10

0 points - no task is completed, or less than 30% of tasks are completed;

4 points - completed at least 30% of tasks;

7 points - completed at least 60% of tasks;

10 points - completed at least 90% of tasks.

The maximum total score for the test during the semester is:

$$n_3 * r_{vcw} = 10*1 = 10$$

Execution of the Final Test Work:

- Creative work - 20 points;

- The work was performed with minor shortcomings - 15 points;

- The work is done with certain errors - 12-10 points:

- Work is not credited (task not completed or there are gross errors) <10 points.

The maximum total score for the test during the semester is:

$$n_4 * r_{ftw} = 20*1 = 20$$

The examination component is 40% of the rating scale and is R_E = 40 points

Rating scale, final grade from the credit module.

The rating scale for the discipline R_D is formed from the total weight score for work in the semester:

$$R_D = n_1 * r_{lc} + n_2 * r_{pc} + n_3 * r_{mcw} + n_4 * r_{ftw} + R_E = 7 \cdot 5 + 10 \cdot 0.5 + 10 \cdot 1 + 20 \cdot 1 + 40 = 100 \text{ points}$$

The condition for admission to the exam is the successful completion of all tests, as well as a starting rating of at least 30 points.

In the exam, students solve two problems and give an oral answer to two theoretical questions. Each task in the ticket is evaluated in 10 points according to the following criteria:

- "Excellent", complete answer, not less than 90% of the required information (complete, error-free problem solving) - 20-17 points;

- "Good", a fairly complete answer, at least 75% of the required information or minor inaccuracies (complete solution of the problem with minor inaccuracies) - 16-13 points;

- "Satisfactory", incomplete answer, not less than 60% of the required information and some errors (the task is performed with certain shortcomings) - 12-8 points;

- "Unsatisfactory", the answer does not meet the conditions for "satisfactory" - 0 points.

To objectively assess the student's knowledge, the teacher has the right to ask additional questions from the course program, which are not contained in the ticket.

Table of translation of rating points to grades on a university scale:

Number points	Assessment on the university scale
100-95	Perfectly / Відмінно
94-85	Very good / Дуже добре
84-75	Good / Добре
74-65	Satisfactorily / Задовільно
64-60	Enough / Достатньо
Less 60	Unsatisfactorily / Незадовільно
Admission conditions are not met	Not allowed / Не допущено

8. Additional information on the discipline (educational component)

• *The list of questions is given in the KPI Electronic Campus named after Igor Sikorsky and in the course folder on the Sikorsky platform.*

• *Certificates of distance or online courses on the subject can be credited subject to the requirements set out in the ORDER № 7-177 FROM 01.10.2020 "On approval of the provisions on recognition in the KPI. Igor Sikorsky learning outcomes acquired in non-formal / informal education.*

Work program of the discipline (syllabus):

Compiled by a senior lecturer, Ph.D., Khist V.V.

Approved by the Department of General and Experimental Physics and the Department of General and Theoretical Physics (minutes of the joint meeting of the departments № 1 from 22.06.2021), reorganized from 01.07.2021 into the Department of General Physics.

Approved by the Methodical Commission of the Faculty of Physics and Mathematics (protocol № _11_ from 23.06.2021)