MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE REPUBLIC OF KAZAKHSTAN

SATBAYEV UNIVERSITY

(Kazakh National Research Technical University named after K.I. Satbayev)

Module reference book or collection of module descriptions in the specialty

7M05301 - "Applied and engineering physics"

Almaty 2025

A module reference book or a collection of module descriptions, which is also available to students for review, should contain the following information about individual modules:

CYCLE OF GENERAL EDUCATION DISCIPLINES (GED)

CYCLE OF BASIC DISCIPLINES (BD)

Module designation	**Module of basic training**
Semester(s) in which the module is taught	**Autumn (1), Spring (2)**
The person responsible for the module	Mendybayev S.K., Zykova N.M., Zhunusova A.K.
Language	Kazakh / Russian / English
Attitude to the curriculum	Cycle of Basic Disciplines (BD), University Component (UC)
Teaching methods	Lecture, practical classes
Workload (including contact hours, self-study hours)	Total workload: 12 ECTS (360 hours) Approximate distribution: Contact hours – 120 hours Independent study – 240 hours
Credits	12 ECTS
Necessary and recommended prerequisites for joining the module	Bachelor’s degree in Applied Physics, Engineering Physics, Materials Science, or a related field. Basic knowledge of general and modern physics, mathematics, and scientific methodology. Basic competencies in academic communication, information analysis, and independent learning. Elementary skills in reading and understanding scientific literature in English are recommended.
Module objectives / expected learning outcomes	The aim of the module is to provide master’s students with fundamental interdisciplinary competencies necessary for professional, pedagogical, and research activities in applied and engineering physics. Upon completion of the module, master’s students are able to: • communicate effectively in a foreign language within professional and academic contexts; • analyze scientific literature and present research results in written and oral form; • understand the historical development and philosophical foundations of modern science; • apply methodological principles of scientific knowledge in physics and engineering research; • demonstrate basic competencies in higher education pedagogy and educational technologies; • apply principles of management psychology in academic and research environments; • develop communication and leadership skills for teamwork in scientific and educational projects; • demonstrate ethical and professional standards in academic and research activities.

	The module forms the general scientific, communicative, and pedagogical foundation necessary for further specialized training in applied and engineering physics at the master's level.
Description	This module provides fundamental training for master's students aimed at developing academic communication skills, understanding the philosophical and historical foundations of science, and acquiring pedagogical and managerial competencies necessary for professional activity in science and higher education. The module includes the following disciplines: Foreign Language (Professional) – development of professional communication skills in a foreign language, including reading and analysis of scientific texts, academic writing, presentations, and participation in international scientific communication. Psychology of Management – study of psychological principles of leadership, organizational behaviour, motivation, decision-making, and effective management in scientific and educational environments. History and Philosophy of Science – analysis of the historical development of scientific knowledge, philosophical foundations of scientific methodology, and the role of science in modern society and technological development. Higher School Pedagogy – theoretical and practical foundations of teaching in higher education, modern pedagogical approaches, curriculum design, and the use of innovative educational technologies. The module promotes development of critical thinking, communication skills, pedagogical competencies, and understanding of the social and philosophical context of scientific research.
Exams and assessment formats	Assessment includes: • analytical essays and written assignments; • presentations and oral reports; • analysis of scientific literature; • pedagogical tasks and teaching demonstrations; • written examinations. Evaluation focuses on the level of theoretical understanding, analytical skills, communication competence, and the ability to apply interdisciplinary knowledge in academic and professional contexts. Assessment is conducted in accordance with university regulations.
Requirements for studies and exams	Successful completion of the module requires: • active participation in lectures, seminars, and practical classes; • completion of individual and group assignments;

	• preparation of analytical and written academic work; • successful completion of final examinations. Master's students must obtain at least 60 out of 100 points in each discipline.
Reading list	1. Harmer J. How to Teach English. Longman. 2. Robbins S., Judge T. Organizational Behavior. Pearson. 3. Kuhn T. The Structure of Scientific Revolutions. University of Chicago Press. 4. Biggs J., Tang C. Teaching for Quality Learning at University. McGraw-Hill. 5. Creswell J. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage.

Module designation	**Module of theoretical training**
Semester(s) in which the module is taught	**Autumn (1)**
The person responsible for the module	Baytimbetova B.A., Beisebayeva A.S.
Language	Kazakh / Russian / English
Attitude to the curriculum	Basic and Profile Disciplines Cycles (BD), Component of Choice (CCH)
Teaching methods	Lecture, practical classes, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 15 ECTS (450 hours) Approximate distribution: Contact hours –135 hours Independent study – 315 hours
Credits	15 ECTS
Necessary and recommended prerequisites for joining the module	Bachelor's degree in Physics, Applied Physics, Engineering Physics, Materials Science, or a related field. Basic knowledge in the following areas is required: • classical and modern physics; • thermodynamics and statistical physics; • solid state physics and materials science; • mathematical methods of physics. Recommended prerequisites include basic research skills, ability to analyze scientific literature, and understanding of the fundamentals of academic ethics and research methodology.
Module objectives / expected learning outcomes	The aim of the module is to develop advanced theoretical knowledge and analytical competencies required for professional and research activities in applied and engineering physics. Upon completion of the module, master's students are able to: • explain the fundamental physical principles governing the structure and properties of solid materials;

	• analyze crystal structures, lattice defects, and physical properties of crystalline materials; • apply thermodynamic laws and methods to analyze physical and technological systems; • interpret phase transitions, equilibrium states, and energy processes in materials; • use theoretical models to explain physical phenomena in modern engineering and technological systems; • understand legal and organizational aspects of intellectual property protection in scientific research; • identify and protect scientific and technological results through patents and other intellectual property mechanisms; • integrate theoretical knowledge with research tasks in applied and engineering physics. The module forms the fundamental theoretical basis for advanced study and research activities within the master's programme in applied and engineering physics.
Description	This module provides theoretical preparation for master's students in applied and engineering physics, focusing on the physical principles governing materials, energy processes, and scientific innovation. The module includes the following disciplines: PHY292 Solid State Physics and Crystallography 1 The course introduces fundamental concepts of solid state physics and crystallography, including crystal lattices, symmetry, crystal structures, and defects in solids. Students study the relationship between atomic structure and physical properties of materials, as well as methods for structural analysis of crystalline materials. PHY244 Thermodynamics 1 This course covers the fundamental laws of thermodynamics, thermodynamic systems and processes, energy transformations, entropy, equilibrium states, and phase transitions. The course provides theoretical tools for analyzing physical processes in materials, energy systems, and technological applications. MNG781 Intellectual Property and Research This course introduces principles of intellectual property protection in scientific and technological activities. Topics include patents, copyrights, licensing, technology transfer, research ethics, and protection of scientific results. The course also discusses commercialization of research outcomes and legal aspects of innovation. The module emphasizes analytical thinking, theoretical modeling of physical systems, understanding of material properties, and awareness of legal aspects related to scientific research and technological development.

Exams and assessment formats	Assessment includes: • written examinations; • problem-solving assignments; • analytical essays and reports; • oral presentations; • individual research-related assignments. Evaluation focuses on the level of theoretical understanding, analytical skills, the ability to apply physical principles to real systems, and awareness of intellectual property issues in scientific research. Assessment is conducted in accordance with university academic regulations.
Requirements for studies and exams	Successful completion of the module requires: • regular attendance and active participation in lectures and seminars; • completion of theoretical and analytical assignments; • preparation of written reports and presentations; • successful completion of examinations in each discipline. Master's students must obtain at least 60 out of 100 points in each discipline in accordance with university assessment standards.
Reading list	1. Kittel C. Introduction to Solid State Physics. Wiley. 2. Ashcroft N., Mermin N. Solid State Physics. Brooks/Cole. 3. Callen H. Thermodynamics and an Introduction to Thermostatistics. Wiley. 4. Atkins P., de Paula J. Physical Chemistry. Oxford University Press. 5. WIPO. Understanding Intellectual Property. World Intellectual Property Organization.

Module designation	**Materials Science Module**
Semester(s) in which the module is taught	**Autumn (1)**
The person responsible for the module	Aimagambetov K.B.
Language	Kazakh / Russian / English
Attitude to the curriculum	Basic and Profile Disciplines Cycles (BD), Component of Choice (CCH)
Teaching methods	Lecture, practical classes, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 10 ECTS (300 hours) Approximate distribution:

	Contact hours (practical classes) – 90 hours Independent study – 210 hours
Credits	10 ECTS
Necessary and recommended prerequisites for joining the module	Bachelor's degree in Physics, Applied Physics, Engineering Physics, Materials Science, or a related field. Students are expected to have fundamental knowledge in: • solid-state physics; • crystallography and structure of materials; • basic semiconductor physics; • thermodynamics and physical chemistry of materials. Recommended prerequisites include basic laboratory skills in materials characterization, familiarity with scientific literature, and elementary knowledge of modern materials used in electronic technologies.
Module objectives / expected learning outcomes	The aim of the module is to develop theoretical and applied knowledge related to the structure, properties, and technological applications of modern materials used in applied and engineering physics. Upon completion of the module, master's students are able to: • explain the physical principles governing the structure and properties of modern materials; • analyze relationships between material structure, composition, and functional properties; • describe synthesis and processing technologies of advanced materials; • evaluate materials used in microelectronics and nanoelectronics; • apply theoretical knowledge to the design and analysis of materials for electronic and technological applications; • understand the role of advanced materials in modern high-technology industries; • interpret experimental data related to material characterization; • critically evaluate scientific literature related to materials science and advanced materials technologies. The module forms an important scientific foundation for further research and technological development in applied physics, materials science, microelectronics, and nanotechnology.
Description	The Materials Science Module focuses on the study of modern materials and technologies used in applied and engineering physics. The module provides theoretical knowledge and practical understanding of the structure, properties, and technological applications of advanced materials. The module includes the following disciplines: PHY291 Materials Science and Advanced Materials Technology 1

	This course introduces the fundamental principles of materials science, including the structure of solids, crystal defects, phase transformations, and relationships between microstructure and physical properties of materials. The course also covers modern technologies for the synthesis and processing of advanced functional materials used in engineering and high-technology industries. PHY774 Materials and Components for Micro- and Nanoelectronics This course focuses on materials used in microelectronic and nanoelectronic devices, including semiconductor materials, dielectric materials, thin films, and nanostructured materials. Students study the physical principles governing the operation of electronic components, fabrication technologies, and the role of materials in the development of modern electronic devices and integrated systems. The module emphasizes the understanding of structure–property relationships, modern materials technologies, and the role of advanced materials in electronic and nanotechnological applications.
Exams and assessment formats	Assessment includes: • written examinations; • problem-solving assignments; • analytical reports and essays; • presentations on modern materials technologies; • laboratory reports and coursework assignments. Evaluation focuses on theoretical understanding, analytical thinking, ability to interpret material properties, and application of materials science principles to engineering and technological problems. Assessment is conducted in accordance with university academic regulations.
Requirements for studies and exams	Successful completion of the module requires: • regular attendance and active participation in lectures and seminars; • completion of analytical assignments and laboratory work; • preparation of reports and presentations on materials science topics; successful completion of final examinations in each discipline. Master's students must obtain at least 60 out of 100 points in each discipline in accordance with university assessment standards.
Reading list	1. Callister W., Rethwisch D. Materials Science and Engineering: An Introduction. Wiley. 2. Kittel C. Introduction to Solid State Physics. Wiley.

	3. Sze S., Ng K. Physics of Semiconductor Devices. Wiley. 4. Cao G., Wang Y. Nanostructures and Nanomaterials: Synthesis, Properties and Applications. World Scientific. 5. Ohring M. Materials Science of Thin Films. Academic Press.

Module designation	**Nanotechnology module**
Semester(s) in which the module is taught	**Autumn (3)**
The person responsible for the module	Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Basic and Profile Disciplines Cycles (BD), Component of Choice (CCH)
Teaching methods	Lecture, practical classes, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 15 ECTS (450 hours) Approximate distribution: Contact hours (practical classes) – 135 hours Independent study – 315 hours
Credits	15 ECTS
Necessary and recommended prerequisites for joining the module	Bachelor’s degree in Physics, Applied Physics, Engineering Physics, Materials Science, Nanotechnology, or a related field. Students are expected to have basic knowledge in: • solid-state physics and materials science; • fundamentals of nanoscience and nanotechnology; • physical chemistry of materials; • basic computer and information technologies. Recommended prerequisites include elementary knowledge of materials synthesis methods, laboratory techniques, and basic skills in data processing and analysis.
Module objectives / expected learning outcomes	The aim of the module is to develop theoretical knowledge and practical competencies related to nanomaterials, modern information technologies in scientific research and production, and sustainable technological development. Upon completion of the module, master’s students are able to: • explain the physical principles underlying the formation and properties of nanomaterials and nanostructures; • describe modern synthesis methods of nanomaterials and nanostructures; • analyze relationships between structure, size effects, and physical properties of nanomaterials; • apply information technologies for data processing, modeling, and analysis in scientific and engineering activities;

	- use modern digital tools and software in scientific research and technological production processes; - understand the principles and strategies of sustainable development in science and technology; - evaluate technological solutions in terms of environmental, economic, and social sustainability; - integrate nanotechnology, information technologies, and sustainability principles in solving scientific and engineering problems. The module prepares master's students for research, technological development, and innovation activities in nanotechnology and applied physics.
Description	The Nanotechnology Module focuses on modern approaches to the synthesis of nanomaterials, application of information technologies in scientific research and production, and the integration of sustainable development principles into technological innovation. The module includes the following disciplines: PHY295 Synthesis Methods of Nanomaterials and Nanostructures 1 This course studies modern physical and chemical methods used for the synthesis of nanomaterials and nanostructures. Topics include bottom-up and top-down fabrication techniques, thin film deposition, nanoparticle synthesis, and nanostructure fabrication methods. Students analyze the influence of synthesis conditions on the structural and physical properties of nanomaterials. PHY279 Information Technologies in Science and Production 1 This course focuses on the application of modern information technologies in scientific research and industrial production. Topics include data processing, numerical analysis, modeling and simulation tools, and the use of digital platforms for scientific communication and research management. MNG782 Sustainable Development Strategies This course introduces the principles of sustainable development and their application in scientific, technological, and industrial contexts. Students study environmental, economic, and social aspects of sustainable technologies, as well as strategies for responsible innovation and sustainable resource management. The module emphasizes integration of nanotechnology, digital technologies, and sustainability principles in modern scientific and technological development.
Exams and assessment formats	Assessment includes: - written examinations; - analytical essays and reports; - laboratory and project assignments;

	• presentations on nanotechnology and sustainability topics; • coursework and individual research-related assignments. Evaluation focuses on theoretical understanding, analytical abilities, application of modern technologies in research and production, and awareness of sustainability challenges in technological development. Assessment is conducted in accordance with university academic regulations.
Requirements for studies and exams	Successful completion of the module requires: • regular attendance and active participation in lectures and seminars; • completion of laboratory work and project assignments; • preparation of analytical reports and presentations; • successful completion of examinations in each discipline. Master's students must obtain at least 60 out of 100 points in each discipline in accordance with university assessment standards.
Reading list	• Cao G., Wang Y. Nanostructures and Nanomaterials: Synthesis, Properties and Applications. World Scientific. • Poole C., Owens F. Introduction to Nanotechnology. Wiley. • Thijssen J. Computational Physics. Cambridge University Press. • Laudon K., Laudon J. Management Information Systems. Pearson. • Boyle G. Renewable Energy: Power for a Sustainable Future. Oxford University Press.

Module designation	**Practice-oriented module**
Semester(s) in which the module is taught	**Autumn (3)**
The person responsible for the module	Nugumanova K.
Language	Kazakh / Russian / English
Attitude to the curriculum	Cycle of Basic Disciplines (BD), University Component (UC)
Workload (including contact hours, self-study hours)	Total workload: 8 ECTS
Credits	8 ECTS
Necessary and recommended prerequisites for joining the module	Completion of the main theoretical and professional disciplines of the master's curriculum. Basic knowledge of pedagogy, psychology of education, and teaching methodology in higher education. Fundamental knowledge in applied and engineering physics

	sufficient for teaching undergraduate-level courses. Basic competencies in academic communication, presentation skills, and scientific ethics are recommended.
Module objectives / expected learning outcomes	The aim of the module is to develop pedagogical and professional competencies required for teaching activities in higher education institutions in the field of applied and engineering physics. Upon completion of the module, master's students are able to: • plan and conduct lectures, seminars, and laboratory classes in physics under academic supervision; • apply modern pedagogical approaches and educational technologies in teaching physics; • prepare educational and methodological materials, including lecture notes, presentations, and laboratory instructions; • organize and supervise laboratory work and student practical activities; • evaluate student learning outcomes using modern assessment methods; • integrate modern scientific knowledge in applied and engineering physics into the educational process; • develop communication, organizational, and leadership skills in academic environments; • demonstrate academic integrity and professional responsibility in teaching activities. The module prepares master's students for professional pedagogical activity in higher education and scientific-educational institutions.
Description	The Practice-Oriented Module includes AAP273 Pedagogical Practice, which is aimed at developing teaching competencies and practical pedagogical experience in higher education. During pedagogical practice, master's students: • participate in teaching activities within the department of physics or related disciplines; • assist in the preparation and delivery of lectures, seminars, and laboratory classes; • develop educational and methodological materials for physics courses; • participate in the assessment of students' academic performance; • supervise laboratory work and assist students in practical and research tasks; • apply modern digital tools and interactive teaching methods in the educational process. The practice is conducted under the supervision of an experienced academic mentor and provides practical experience in teaching physics, organizing laboratory work, and applying modern educational technologies in higher education.
Exams and assessment formats	Assessment is based on:

	evaluation by the academic supervisor of pedagogical practice; observation and assessment of teaching performance during classes; pedagogical practice reports; presentation and defense of practice outcomes before the departmental committee. Evaluation criteria include the quality of teaching preparation, communication skills, pedagogical effectiveness, and ability to apply modern teaching methods. Assessment is conducted in accordance with university academic regulations.
Requirements for studies and exams	Successful completion of the module requires: full implementation of the approved pedagogical practice plan; active participation in teaching activities and academic classes; preparation of educational and methodological materials; submission of a detailed pedagogical practice report; positive evaluation by the academic supervisor. The final evaluation is based on cumulative assessment of pedagogical performance and the successful defense of the practice report.
Reading list	1. Biggs J., Tang C. Teaching for Quality Learning at University. McGraw-Hill. 2. Brown G., Atkins M. Effective Teaching in Higher Education. Routledge. 3. Brookfield S. The Skillful Teacher. Jossey-Bass. 4. Healey M., Jenkins A. Developing Undergraduate Research and Inquiry. Higher Education Academy. 5. University internal regulations on pedagogical practice and academic ethics.

CYCLE OF PROFILE DISCIPLINES (PD)

Module designation	**Materials Science Module**
Semester(s) in which the module is taught	**Autumn (3), Spring (4)**
The person responsible for the module	Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Cycle of Profile Disciplines (PD), Component of Choice (CCH), University Component (UC)
Workload (including contact hours, self-study hours)	Total workload: 14 ECTS (420 hours) Approximate distribution: Contact hours (practical classes) – 135 hours Independent study – 285 hours
Credits	14 ECTS
Necessary and recommended prerequisites for joining the module	Successful completion of the basic and theoretical training modules within the master's curriculum. Students are expected to possess fundamental knowledge in:

	• solid-state physics and materials science; • quantum physics and modern physical technologies; • basic research methodology and data analysis. Recommended prerequisites include familiarity with modern technological applications of physics, as well as basic competencies in scientific communication and project-based work.
Module objectives / expected learning outcomes	The aim of the module is to develop advanced professional competencies required for research, technological development, and project management in applied and engineering physics. Upon completion of the module, master's students are able to: • analyze modern approaches to project management in scientific and technological environments; • plan and manage research and engineering projects in applied physics; • explain fundamental principles of quantum technologies and quantum engineering; • analyze the operation of quantum systems and devices used in modern technological applications; • evaluate properties and technological applications of advanced structural materials; • apply modern physical knowledge to engineering and technological challenges; • critically analyze scientific literature related to emerging physical technologies and materials; • integrate knowledge of advanced materials, quantum technologies, and project management in solving complex scientific and engineering problems. The module strengthens the ability of master's students to operate in high-technology environments, research laboratories, and innovation-oriented industries.
Description	The Advanced Professional Module focuses on modern technological developments in applied and engineering physics, including quantum technologies, advanced materials, and project management in scientific and technological fields. The module includes the following disciplines: MNG705 Project Management 1 This course introduces principles and methods of project management applicable to scientific research and technological development. Topics include project planning, resource management, risk assessment, teamwork, project evaluation, and management of research and innovation projects. PHY775 Quantum Technologies and Quantum Engineering 1 This course examines fundamental principles and technological applications of quantum systems, including quantum information processing, quantum computing, quantum communication, and quantum sensing. Students study the

	physical basis of quantum technologies and their potential impact on modern science and industry. PHY772 Advanced Structural Materials This course focuses on modern structural materials used in engineering and high-technology industries. Topics include mechanical and physical properties of advanced materials, composite materials, high-strength alloys, and functional materials used in modern engineering applications. The module emphasizes advanced technological knowledge, interdisciplinary integration, and application of modern physical principles to engineering and research problems.
Exams and assessment formats	Assessment includes: • written examinations; • analytical essays and reports; • project-based assignments; • oral presentations; • coursework and case-study analyses. Evaluation focuses on theoretical understanding, analytical skills, ability to apply knowledge to technological and research problems, and effective participation in project-based activities. Assessment is conducted in accordance with university academic regulations.
Requirements for studies and exams	Successful completion of the module requires: • active participation in lectures, seminars, and project activities; • completion of analytical assignments and reports; • preparation of presentations and project documentation; • successful completion of final examinations in each discipline. Master's students must obtain at least 60 out of 100 points in each discipline in accordance with university assessment standards.
Reading list	1. Nielsen M., Chuang I. Quantum Computation and Quantum Information. Cambridge University Press. 2. Callister W., Rethwisch D. Materials Science and Engineering: An Introduction. Wiley. 3. Kerzner H. Project Management: A Systems Approach to Planning, Scheduling, and Controlling. Wiley. 4. Ashcroft N., Mermin N. Solid State Physics. Brooks/Cole. 5. Cao G., Wang Y. Nanostructures and Nanomaterials: Synthesis, Properties and Applications. World Scientific.

Module designation	**Nanotechnology module**

Semester(s) in which the module is taught	**Autumn (3)**
The person responsible for the module	Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Cycle of Profile Disciplines (PD), Component of Choice (CCH)
Workload (including contact hours, self-study hours)	Total workload: 10 ECTS (300 hours) Approximate distribution: Contact hours (practical classes) – 90 hours Independent study – 210 hours
Credits	10 ECTS
Necessary and recommended prerequisites for joining the module	Successful completion of the basic and theoretical training modules within the master's curriculum. Students are expected to possess fundamental knowledge in: • solid-state physics and materials science; • nanoscience and nanotechnology; • thermodynamics and physical chemistry of materials; • basic research methodology and data analysis. Recommended prerequisites include familiarity with modern nanomaterials, energy-related technologies, and basic competencies in scientific communication and analytical work.
Module objectives / expected learning outcomes	The aim of the module is to develop advanced scientific and technological competencies related to modern functional materials, including carbon low-dimensional materials and materials used for energy storage and conversion. Upon completion of the module, master's students are able to: • explain the physical principles underlying the formation and properties of low-dimensional carbon materials; • analyze synthesis methods and technological processes for producing carbon nanomaterials; • evaluate structural, electronic, and mechanical properties of graphene, carbon nanotubes, and related materials; • analyze materials used in modern energy storage and energy conversion technologies; • explain physical and chemical processes occurring in batteries, supercapacitors, and energy conversion systems; • interpret experimental and theoretical data related to nanomaterials and energy materials; • critically analyze scientific literature related to advanced functional materials and energy technologies; • apply knowledge of nanomaterials and energy materials in solving scientific and technological problems. The module strengthens the ability of master's students to work in research laboratories, energy technology development, and advanced materials engineering.

Description	The Advanced Materials and Energy Technologies Module focuses on modern materials used in nanotechnology and energy-related applications, including carbon-based low-dimensional materials and materials for energy storage and conversion systems. The module includes the following disciplines: PHY700 Production, Properties, and Application of Carbon Low-Dimensional Materials This course examines the synthesis, physical properties, and technological applications of carbon-based low-dimensional materials, such as graphene, carbon nanotubes, and related nanostructures. Students study production methods, structural characteristics, electronic and mechanical properties, and the role of these materials in modern nanotechnology and electronic devices. PHY266 Materials for Energy Storage and Conversion This course focuses on materials used in modern energy technologies, including batteries, supercapacitors, fuel cells, and other energy conversion systems. Students study the physical and chemical processes governing energy storage and conversion, as well as the properties and technological applications of advanced functional materials used in these systems. The module emphasizes modern materials technologies, energy-related applications, and the integration of nanomaterials into advanced energy systems.
Exams and assessment formats	Assessment includes: • written examinations; • analytical essays and scientific reports; • problem-solving assignments; • presentations on advanced materials and energy technologies; • coursework and case-study analyses. Evaluation focuses on theoretical understanding, analytical skills, and the ability to apply materials science and nanotechnology principles to modern energy and technological challenges. Assessment is conducted in accordance with university academic regulations.
Requirements for studies and exams	Successful completion of the module requires: • active participation in lectures and seminars; • completion of analytical assignments and reports; • preparation of presentations and coursework; • successful completion of final examinations in each discipline. Master's students must obtain at least 60 out of 100 points in each discipline in accordance with university assessment standards.

Reading list	1. Dresselhaus M., Dresselhaus G., Avouris P. Carbon Nanotubes: Synthesis, Structure, Properties, and Applications. Springer. 2. Geim A., Novoselov K. Graphene: Fundamentals and Emergent Applications. Elsevier. 3. Cao G., Wang Y. Nanostructures and Nanomaterials: Synthesis, Properties and Applications. World Scientific. 4. Winter M., Brodd R. What Are Batteries, Fuel Cells, and Supercapacitors? Chemical Reviews. 5. Goodenough J., Park K. The Li-Ion Rechargeable Battery: A Perspective. Journal of the American Chemical Society.

Module designation	**R&D module**
Semester(s) in which the module is taught	**Autumn (3)**
The person responsible for the module	Baytimbetova B.A., Beisebayeva
Language	Kazakh / Russian / English
Attitude to the curriculum	Cycle of Profile Disciplines (PD), Component of Choice (CCH)
Teaching methods	Lecture, practical classes, research seminars, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 10 ECTS (300 hours) Approximate distribution: Contact hours (practical classes) – 90 hours Independent study – 210 hours
Credits	10 ECTS
Necessary and recommended prerequisites for joining the module	Completion of the Materials Science and Nanotechnology modules within the master's curriculum. Students are expected to have knowledge in: • solid-state physics and materials science; • nanomaterials and low-dimensional systems; • basic principles of experimental physics and materials characterization; • research methodology and data analysis. Recommended prerequisites include basic understanding of laboratory techniques for studying material structure and properties, as well as familiarity with scientific literature in materials science and nanotechnology.
Module objectives / expected learning outcomes	The aim of the module is to develop advanced competencies in modern experimental methods for structural and spectral characterization of nanomaterials and low-dimensional systems. Upon completion of the module, master's students are able to: • explain physical principles of electron and probe microscopy used for studying nanomaterials;

	• analyze structural and morphological properties of materials at the micro- and nanoscale; • apply spectral methods for studying low-dimensional objects and nanostructures; • interpret experimental data obtained using advanced characterization techniques; • evaluate advantages and limitations of different microscopy and spectroscopy methods; • critically analyze scientific literature related to nanomaterial characterization; • integrate structural and spectral analysis methods in research on advanced materials. The module supports preparation for independent experimental research and advanced materials characterization in applied physics and nanotechnology.
Description	The Advanced Characterization Methods for Nanomaterials Module focuses on modern experimental techniques used to study the structure, morphology, and physical properties of nanomaterials and low-dimensional systems. The module includes the following disciplines: PHY701 Electron and Probe Microscopy for Studying Nanomaterials 1 This course introduces the principles and applications of electron microscopy and scanning probe microscopy in nanomaterials research. Students study techniques such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), and scanning tunneling microscopy (STM). The course emphasizes structural analysis, imaging at the nanoscale, and interpretation of microscopy data. PHY299 Spectral Methods for Studying Low-Dimensional Objects This course focuses on spectral techniques used for the investigation of nanostructures and low-dimensional materials. Topics include optical spectroscopy, Raman spectroscopy, photoluminescence spectroscopy, and other methods used to analyze electronic, vibrational, and optical properties of nanomaterials. The module emphasizes modern experimental techniques, nanoscale analysis, and integration of structural and spectral methods for advanced materials research.
Exams and assessment formats	Assessment includes: • laboratory reports; • analytical essays and research reviews; • problem-solving assignments; • presentations on experimental techniques; • written examinations.

	Evaluation focuses on theoretical understanding, ability to interpret experimental results, and competence in applying advanced characterization techniques in materials research. Assessment is conducted in accordance with university academic regulations.
Requirements for studies and exams	Successful completion of the module requires: • active participation in lectures, seminars, and laboratory sessions; • completion of laboratory and analytical assignments; • preparation of reports and presentations; • successful completion of final examinations in each discipline. Master's students must obtain at least 60 out of 100 points in each discipline in accordance with university assessment standards.
Reading list	1. Williams D., Carter C. Transmission Electron Microscopy: A Textbook for Materials Science. Springer. 2. Binnig G., Rohrer H. Scanning Tunneling Microscopy. Springer. 3. Cullity B., Stock S. Elements of X-Ray Diffraction. Pearson. 4. Ferraro J., Nakamoto K., Brown C. Introductory Raman Spectroscopy. Academic Press. 5. Cao G., Wang Y. Nanostructures and Nanomaterials: Synthesis, Properties and Applications. World Scientific.

Module designation	**Practice-oriented module**
Semester(s) in which the module is taught	**Spring (4)**
The person responsible for the module	Nugumanova K.
Language	Kazakh / Russian / English
Attitude to the curriculum	Profile Disciplines Cycles (PD), University Component (UC)
Teaching methods	Lecture, practical classes, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 4 ECTS
Credits	4 ECTS
Necessary and recommended prerequisites for joining the module	Completion of the core theoretical modules within the master's curriculum. Knowledge of research methodology and scientific writing. Approved practice plan by the academic supervisor. Basic competencies in laboratory work, data analysis, and materials characterization
Module objectives / expected learning outcomes	The aim of the module is to develop professional, pedagogical, and research competencies required for academic and industrial practice at the master's level. Upon completion of the module, master's students are able to:

	• design and conduct educational activities in higher education settings; • apply modern teaching methods and interactive learning approaches; • organize and perform experimental research in materials science and applied physics; • analyze and interpret experimental and computational data; • prepare scientific reports, presentations, and research documentation; • demonstrate professional communication skills in academic and industrial environments; • integrate theoretical knowledge with practical and research experience. The module ensures the development of applied research skills, pedagogical competence, and professional readiness for academic and industrial careers.
Description	The Practice-Oriented Module combines pedagogical practice and research practice: Pedagogical Practice: • Development of teaching skills in higher education institutions. • Preparation and delivery of lectures, seminars, and practical classes. • Participation in assessment activities and student mentoring. Research Practice: • Hands-on experience in laboratory and industrial environments. • Participation in experimental studies and materials characterization. • Data collection, analysis, and preparation of scientific documentation. The module ensures integration between teaching, research, and practical industrial applications.
Exams and assessment formats	Assessment is based on: • evaluation by the academic supervisor; • submission of practice reports; • presentation and defense of practice results before a departmental commission; • compliance with the approved practice program. Evaluation criteria include quality of reports, practical performance, research and teaching effectiveness, and defense skills. Assessment follows university regulations.
Requirements for studies and exams	Successful completion requires: • full implementation of the approved practice program;

	• active participation in pedagogical and research activities; • submission of written reports and presentations; • successful defense of practice results before the departmental committee. The final grade is assigned based on supervisor evaluation, quality of documentation, and defense performance.
Reading list	1. Biggs J., Tang C. Teaching for Quality Learning at University. McGraw-Hill. 2. Creswell J. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications. 3. ASM Handbook (selected volumes related to laboratory and industrial practice). 4. University guidelines for pedagogical and research practice.

Module designation	**Experimental research module**
Semester(s) in which the module is taught	**Autumn, spring (1, 2, 3, 4)**
The person responsible for the module	Kudaibergenov K.K., Smagulov D.U., Kerimkulova A.Y., Beisebayeva A.S.
Language	Kazakh / Russian / English
Attitude to the curriculum	Research Work of Master's Student (RWMS) – Mandatory Component
Teaching methods	Lecture, practical classes, research seminars, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 24 ECTS
Credits	24 ECTS
Necessary and recommended prerequisites for joining the module	Enrollment in the Master's programme 7M05301 – Applied and Engineering Physics. Completion of core theoretical modules within the curriculum. Approval of research topic and assignment of a scientific supervisor. Basic competencies in research methodology, data analysis, and academic writing.
Module objectives / expected learning outcomes	The aim of the module is to develop independent scientific research competencies and prepare the master's student for thesis defense. Upon completion of the module, the master's student is able to: • formulate clear research objectives and hypotheses in materials science and applied physics; • design and conduct experimental investigations and computational studies;

	• apply advanced characterization techniques and methods of data analysis; • critically analyze scientific literature in relevant research fields; • interpret experimental and computational results using modern theoretical approaches; • prepare scientific reports, conference papers, and journal articles; • integrate research outcomes into a Master's thesis meeting international scientific standards. This module represents the core research component of the master's educational programme.
Description	The Experimental Research Module involves systematic scientific research conducted under academic supervision throughout the master's study period. Key activities include: • conducting research directly related to the Master's thesis topic; • performing experimental studies, computational modeling, and materials characterization; • developing technological or industrial applications of research results where applicable; • participating in research seminars, scientific discussions, and presentations; • preparing scientific publications and contributing to conferences; • undertaking internship activities in laboratory or industrial environments. The research outcomes serve as the basis for the final Master's thesis.
Exams and assessment formats	Assessment is conducted through: • submission of interim research reports each semester; • evaluation of research progress by the academic supervisor; • presentation of results at departmental seminars; • approval of thesis readiness for defense. Evaluation is based on established academic regulations, research quality, and cumulative performance.
Requirements for studies and exams	Successful completion requires: • systematic and documented progress in research activities; • submission of semester reports and research documentation; • active participation in scientific seminars and discussions; • confirmation of research results and thesis readiness by the academic supervisor.

	Final assessment is based on cumulative evaluation of research achievements throughout the master's programme.
Reading list	

Module designation	**Module in Applied and Engineering Physics**
Semester(s) in which the module is taught	**Autumn, spring (1, 2)**
The person responsible for the module	Baytimbetova B.A., Beisebayeva A. S
Language	Kazakh / Russian / English
Attitude to the curriculum	Profile Disciplines Cycles (PD), University Component (UC), Component of Choice (CCH)
Teaching methods	Lecture, practical classes, research seminars, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 40 ECTS Approximate distribution: Contact hours (practical classes) – 180 hours
Credits	40 ECTS
Necessary and recommended prerequisites for joining the module	Enrollment in the Master's programme 7M05301 – Applied and Engineering Physics. Completion of core theoretical modules within the curriculum. Approval of research topic and assignment of a scientific supervisor. Basic competencies in research methodology, data analysis, and academic writing.
Module objectives / expected learning outcomes	The aim of the module is to develop independent scientific research competencies and prepare the master's student for thesis defense. Upon completion of the module, the master's student is able to: • formulate clear research objectives and hypotheses in materials science and applied physics; • design and conduct experimental investigations and computational studies; • apply advanced characterization techniques and methods of data analysis; • critically analyze scientific literature in relevant research fields; • interpret experimental and computational results using modern theoretical approaches; • prepare scientific reports, conference papers, and journal articles; • integrate research outcomes into a Master's thesis meeting international scientific standards.

	This module represents the core research component of the master's educational programme.
Description	The Experimental Research Module involves systematic scientific research conducted under academic supervision throughout the master's study period. Key activities include: • conducting research directly related to the Master's thesis topic; • performing experimental studies, computational modeling, and materials characterization; • developing technological or industrial applications of research results where applicable; • participating in research seminars, scientific discussions, and presentations; • preparing scientific publications and contributing to conferences; • undertaking internship activities in laboratory or industrial environments. The research outcomes serve as the basis for the final Master's thesis.
Exams and assessment formats	Assessment is conducted through: • submission of interim research reports each semester; • evaluation of research progress by the academic supervisor; • presentation of results at departmental seminars; • approval of thesis readiness for defense. Evaluation is based on established academic regulations, research quality, and cumulative performance.
Requirements for studies and exams	Successful completion requires: • systematic and documented progress in research activities; • submission of semester reports and research documentation; • active participation in scientific seminars and discussions; • confirmation of research results and thesis readiness by the academic supervisor. Final assessment is based on cumulative evaluation of research achievements throughout the master's programme.
Reading list	

Module designation	**Module of final attestation**
Semester(s) in which the module is taught	**Spring (4)**

The person responsible for the module	Baytimbetova B.A., Beisebayeva
Language	Kazakh / Russian / English
Attitude to the curriculum	Final Attestation (FA) – Mandatory Component
Teaching methods	Lecture, practical classes, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 8 ECTS
Credits	8 ECTS
Necessary and recommended prerequisites for joining the module	Successful completion of all theoretical modules (BD and PD). Completion of Research Work of the Master's Student (RWMS). Completion of pedagogical and research practice. Fulfillment of all academic credit requirements of the master's educational programme.
Module objectives / expected learning outcomes	The aim of the module is to assess achievement of program learning outcomes and confirm the readiness of the master's student for independent scientific and professional activity. Upon completion of the module, the master's student demonstrates the ability to: • formulate and justify a scientific research problem in materials science and applied physics; • apply advanced theoretical and experimental methods in research; • conduct independent research and analyze experimental and computational data; • interpret results using modern scientific and technological approaches; • present research findings in accordance with academic standards; • defend scientific results before an examination committee. This module confirms the student's research competence and readiness for doctoral studies or high-level professional activity.
Description	The Module of Final Attestation includes: • preparation, submission, and public defense of the Master's thesis; • presentation of an independent research project conducted under academic supervision; • integration of theoretical knowledge, experimental skills, and analytical competence developed throughout the programme. • The Master's thesis must demonstrate: • scientific relevance and methodological rigor; • originality in analysis and problem-solving; • practical or theoretical significance in the field of materials science and advanced materials technology.

	The defense is conducted before the State Examination Committee in accordance with national legislation and university regulations.
Exams and assessment formats	Assessment is conducted in the form of: • Public defense of the Master's thesis before the State Examination Committee. Evaluation criteria include: • scientific novelty and relevance of the research; • depth of theoretical analysis; • quality of experimental, computational, or analytical results; • practical significance of findings; • quality and completeness of the written thesis; • quality of oral defense and ability to answer expert questions.
Requirements for studies and exams	Admission to the final attestation is granted to master's students who have: • successfully completed all required modules, research work, and practice components; • fulfilled all credit requirements of the master's programme. The final grade is assigned by the State Examination Committee according to established academic standards and university regulations.
Reading list	1. ECA212 Registration and Protection of the Master's Thesis (university guidelines and templates). 2. Creswell, J. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage Publications. 3. Biggs, J., Tang, C. Teaching for Quality Learning at University. McGraw-Hill. 4. Selected guidelines and internal regulations for Master's thesis preparation, submission, and defense.