

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

8D05301 - "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:

Module designation	Module of basic training
Semester(s) in which the module is taught	Autumn (1)
The person responsible for the module	Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Cycle of Basic Disciplines (BD), University Component (UC), Component of Choice (CCH)
Teaching methods	Lecture, practical classes
Workload (including contact hours, self-study hours)	Total workload: 25 ECTS (750 hours) Approximate distribution: Contact hours – 225 hours Independent study – 525 hours
Credits	25 ECTS
Necessary and recommended prerequisites for joining the module	Master’s degree in Applied Physics, Engineering Physics, Materials Science, or a related field. Basic knowledge of advanced physics, nanostructures, and energy-related technologies. Research experience at the master’s level. Basic competencies in academic writing, research methodology, and scientific communication.
Module objectives / expected learning outcomes	The aim of the module is to develop advanced theoretical, methodological, and interdisciplinary competencies required for independent doctoral research in applied and engineering physics. Upon completion of the module, doctoral students are able to: <ul style="list-style-type: none"> • produce high-quality academic texts suitable for publication in international peer-reviewed journals; • apply advanced research methodologies in experimental and theoretical physics; • design and implement independent scientific research projects; • analyze physical principles of energy saving technologies and renewable energy systems; • investigate synthesis methods and physical properties of low-dimensional structures and nanomaterials; • integrate sustainability principles into modern physical and engineering research; • critically evaluate contemporary scientific literature and technological approaches in applied physics; • demonstrate academic integrity and ethical standards in scientific research. The module forms the methodological and conceptual foundation for doctoral-level research in applied and engineering physics.

Description	<p>This module provides advanced theoretical and methodological training for doctoral students in applied and engineering physics. The module includes the following disciplines:</p> <p>Academic Writing – development of advanced scientific writing skills and preparation of manuscripts for international peer-reviewed journals.</p> <p>Methods of Scientific Research – modern research methodologies, experimental design, and analysis of scientific data.</p> <p>Physics and Technique of Energy Saving and Renewable Energy – physical principles and technologies related to energy efficiency and renewable energy systems.</p> <p>Synthesis and Physical Properties of Low-Dimensional Structures – study of synthesis techniques, characterization methods, and physical properties of nanostructures and low-dimensional materials.</p> <p>Sustainability Science – interdisciplinary approaches to sustainable development and integration of sustainability principles into scientific and technological research.</p> <p>The module emphasizes critical thinking, independent research planning, interdisciplinary integration, and preparation of doctoral students for international scientific publications and advanced research activities.</p>
Exams and assessment formats	<p>Assessment includes:</p> <ul style="list-style-type: none"> • analytical essays; • research proposals; • scientific article drafts; • laboratory and research reports; • oral presentations; • written examinations. <p>Evaluation focuses on originality of thought, methodological rigor, analytical depth, and the ability to develop independent research strategies in applied and engineering physics.</p> <p>Assessment is conducted in accordance with university regulations.</p>
Requirements for studies and exams	<p>Successful completion of the module requires:</p> <ul style="list-style-type: none"> • active participation in seminars and practical classes; • submission of research-oriented assignments; • preparation of publishable academic texts; • successful completion of examinations in each discipline. <p>Doctoral students must obtain at least 60 out of 100 points in each discipline.</p>
Reading list	<ol style="list-style-type: none"> 1. Creswell J. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage.

	<ol style="list-style-type: none"> 2. Booth W., Colomb G., Williams J. The Craft of Research. University of Chicago Press. 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. 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	Spring (2)
The person responsible for the module	Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Basic and Profile Disciplines Cycles (BD), University Component (UC)
Teaching methods	Lecture, practical classes, independent work of students
Workload (including contact hours, self-study hours)	Total workload: 10 ECTS
Credits	10 ECTS
Necessary and recommended prerequisites for joining the module	Enrollment in the PhD program in Applied and Engineering Physics. Completion of the initial theoretical training within the doctoral curriculum. Approved individual doctoral study plan. Basic competencies in scientific communication, academic ethics, and higher education teaching principles.
Module objectives / expected learning outcomes	<p>The aim of the module is to develop advanced pedagogical and research competencies required for academic and scientific careers in applied and engineering physics. Upon completion of the module, doctoral students are able to:</p> <ul style="list-style-type: none"> • independently design and deliver lectures, seminars, and laboratory classes in applied and engineering physics in higher education institutions; • apply modern teaching methodologies and digital educational technologies in physics education; • supervise student research projects and laboratory work in applied physics; • organize and conduct advanced laboratory and experimental activities; • integrate modern research findings in applied and engineering physics into the educational process; • develop educational and methodological materials for physics courses; • demonstrate leadership, academic integrity, and professional responsibility in academic environments. <p>The module prepares doctoral students for teaching activities</p>

	in higher education and advanced research supervision in applied and engineering physics.
Description	The Practice-Oriented Module includes pedagogical practice (AAP350 Pedagogical Practice) aimed at developing teaching skills in higher education. Pedagogical practice involves preparation and delivery of lectures, seminars, and laboratory sessions in applied and engineering physics under academic supervision, development of educational and methodological materials including lecture notes and laboratory instructions, participation in student assessment procedures, supervision of laboratory work and research projects, and application of modern digital educational technologies and interactive teaching methods. The module ensures integration between teaching activities, scientific research, and innovation processes within doctoral training.
Exams and assessment formats	Assessment is based on supervisor evaluation, teaching performance assessment during lectures, seminars and laboratory sessions, reports on pedagogical practice activities, and presentation and defense of practice outcomes before a departmental committee. Evaluation follows university regulations and doctoral-level academic standards.
Requirements for studies and exams	Successful completion requires full implementation of the approved pedagogical practice plan, submission of detailed reports on teaching activities, preparation of educational and methodological materials, documented participation in teaching activities, and positive evaluation by the academic supervisor. Final evaluation is based on cumulative performance assessment and supervisor recommendation.
Reading list	<ol style="list-style-type: none"> 1. Biggs, J., Tang, C. Teaching for Quality Learning at University. McGraw-Hill. 2. Creswell, J. Research Design. Sage. 3. Healey, M., Jenkins, A. Developing Undergraduate Research and Inquiry. Higher Education Academy. 4. Selected international guidelines on doctoral supervision, academic ethics, and higher education teaching practices.

Module designation	Module of professional activity
Semester(s) in which the module is taught	Autumn (1)
The person responsible for the module	Shalenov E., Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Cycle of Profile Disciplines (PD), Component of Choice (CCH)
Teaching methods	Lecture, practical classes, independent work of students

Workload (including contact hours, self-study hours)	Total workload: 20 ECTS (600 hours) Approximate distribution: Contact hours (practical classes) – 180 hours Independent study – 420 hours
Credits	20 ECTS
Necessary and recommended prerequisites for joining the module	Master's degree in Applied Physics, Engineering Physics, Materials Science, or a related engineering or physical science field. Advanced knowledge of solid-state physics, semiconductor physics, and materials characterization methods. Basic skills in computational modeling, numerical simulations, and data analysis relevant to physical systems.
Module objectives / expected learning outcomes	<p>The aim of the module is to develop advanced professional, analytical, and technological competencies required for independent scientific and technological activity in applied and engineering physics. Upon completion of the module, doctoral students are able to:</p> <ul style="list-style-type: none"> • analyze physical processes in semiconductor heterostructures and advanced electronic devices; • apply computational experiment methods for modeling physical systems and technological processes; • use modern artificial intelligence techniques for solving complex computational tasks in physics; • design and implement computational models for physical and engineering applications; • apply advanced physicochemical methods for characterization and analysis of materials; • critically evaluate experimental and theoretical approaches in modern applied physics research; • integrate computational modeling, artificial intelligence tools, and experimental techniques in solving scientific problems; • propose innovative solutions for advanced physical and engineering challenges. <p>The module strengthens the doctoral student's ability to operate at the frontier of applied and engineering physics research.</p>
Description	The Module of Professional Activity focuses on advanced theoretical and applied aspects of applied and engineering physics. The module includes the following disciplines: Semiconductor Heterostructures and Devices Based on Them, Methods of Computational Experiment, Application of Artificial Intelligence for Computational Tasks in Physics, and Physicochemical Methods of Materials Research. The module covers modern approaches to the design and analysis of semiconductor heterostructures, computational modeling of physical processes, application of artificial intelligence techniques in scientific computation, and advanced experimental methods for materials characterization. Special

	emphasis is placed on research-oriented problem solving, integration of computational and experimental approaches, and development of innovative technological solutions in applied physics. The module prepares doctoral students for advanced research activities and leadership roles in scientific laboratories, high-technology industries, and academic institutions.
Exams and assessment formats	Assessment includes research-oriented assignments, analytical reviews of scientific literature, computational and modeling projects, laboratory reports, oral presentations, and written examinations. Evaluation criteria emphasize originality, methodological rigor, analytical depth, and the ability to propose innovative research strategies in applied and engineering physics.
Requirements for studies and exams	Successful completion requires active participation in seminars and research activities, submission of analytical reviews, computational modeling projects, and laboratory reports, as well as successful completion of final examinations in each discipline. Doctoral students must demonstrate advanced scientific reasoning and obtain at least 60 out of 100 total points in each discipline.
Reading list	<ol style="list-style-type: none"> 1. Sze, S., Ng, K. Physics of Semiconductor Devices. Wiley. 2. Kittel, C. Introduction to Solid State Physics. Wiley. 3. Thijssen, J. Computational Physics. Cambridge University Press. 4. Bishop, C. Pattern Recognition and Machine Learning. Springer. 5. Cullity, B., Stock, S. Elements of X-Ray Diffraction. Pearson.

Module designation	Practice-oriented module
Semester(s) in which the module is taught	Autumn (2)
The person responsible for the module	Baytimbetova B.A.
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: 10 ECTS
Credits	10 ECTS
Necessary and recommended prerequisites for joining the module	Enrollment in the PhD program in Applied and Engineering Physics. Completion of the initial theoretical training within the doctoral curriculum. Approved individual doctoral study plan. Basic competencies in research methodology, scientific communication, and academic ethics.

Module objectives / expected learning outcomes	<p>The aim of the module is to develop advanced research competencies required for independent scientific activity in applied and engineering physics. Upon completion of the module, doctoral students are able to:</p> <ul style="list-style-type: none"> • independently plan and conduct advanced experimental and theoretical research in applied and engineering physics; • apply modern experimental techniques and research methodologies in physics and materials science; • analyze and interpret experimental and computational data; • participate in interdisciplinary research projects and collaborate with scientific laboratories and industrial partners; • integrate research results into doctoral dissertation work and scientific publications; • present research findings in scientific reports, seminars, and conferences; • demonstrate academic integrity and professional responsibility in research activities. <p>The module prepares doctoral students for high-level scientific research and independent research activity in academic and technological environments.</p>
Description	<p>The Practice-Oriented Module includes research practice (AAP355 Research Practice) aimed at developing advanced research skills in applied and engineering physics. Research practice involves participation in experimental and theoretical research projects, advanced laboratory work, data analysis, and collaboration with research groups or industrial partners. Doctoral students conduct independent research related to their dissertation topic, apply modern experimental and computational methods, and participate in scientific discussions and seminars. The module ensures integration of scientific research, innovation activities, and doctoral dissertation development.</p>
Exams and assessment formats	<p>Assessment is based on supervisor evaluation, research activity reports, participation in scientific seminars, and presentation and defense of research practice outcomes before a departmental committee. Evaluation follows university regulations and doctoral-level academic standards.</p>
Requirements for studies and exams	<p>Successful completion requires full implementation of the approved research practice plan, submission of detailed research reports, documented participation in scientific activities, and confirmation of research results relevant to the doctoral dissertation. Final evaluation is based on cumulative performance assessment and supervisor recommendation.</p>
Reading list	<ol style="list-style-type: none"> 1. Creswell, J. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. Sage. 2. Booth, W., Colomb, G., Williams, J. The Craft of Research. University of Chicago Press.

	<ol style="list-style-type: none"> 3. Selected international guidelines on doctoral research supervision and academic ethics. 4. University internal regulations for doctoral research practice and scientific activities.
--	--

Module designation	Experimental research module
Semester(s) in which the module is taught	Autumn, spring (1, 2, 3, 4, 5, 6)
The person responsible for the module	Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Research Work of Doctoral Student (RWDS) – Mandatory Component
Workload (including contact hours, self-study hours)	Total workload: 123 ECTS
Credits	123 ECTS
Necessary and recommended prerequisites for joining the module	Admission to the PhD program in Applied and Engineering Physics. Approved doctoral research proposal. Assigned scientific supervisor. Completion of the basic and profile discipline modules within the doctoral curriculum.
Module objectives / expected learning outcomes	<p>The aim of the module is to generate original scientific knowledge and develop independent high-level research competence in applied and engineering physics. Upon completion of the module, doctoral students are able to:</p> <ul style="list-style-type: none"> • formulate novel research hypotheses in applied and engineering physics; • design and implement complex experimental and theoretical research programs; • develop and adapt advanced experimental, computational, and analytical research methodologies; • integrate theoretical modeling, computational simulation, and experimental validation; • critically analyze and synthesize international scientific literature in physics and related interdisciplinary fields; • publish research results in peer-reviewed international scientific journals; • present research findings at international scientific conferences and seminars; • prepare and complete an original doctoral dissertation contributing new scientific knowledge to the field of applied and engineering physics. <p>This module ensures the formation of an independent researcher capable of conducting and leading advanced scientific projects.</p>
Description	The Experimental Research Module constitutes the core of the doctoral program and is conducted continuously throughout all semesters of study. Doctoral students carry out independent

	research aligned with the approved doctoral dissertation topic within the framework of Research Work of the Doctoral Student (RWDS), including research internships and preparation of the doctoral dissertation. Research activities may include theoretical investigations, computational modeling, experimental studies in applied physics, analysis of physical processes in advanced materials and devices, development of innovative technological approaches, and participation in collaborative research projects with scientific laboratories and industrial partners. Doctoral students may also participate in international research internships and academic mobility programs. The results of the module form the scientific basis of the doctoral dissertation and must meet international research standards in applied and engineering physics.
Exams and assessment formats	Assessment is conducted through semester research reports, evaluation by the scientific supervisor, presentation of research progress at departmental scientific seminars, publication of research results in peer-reviewed journals, and confirmation of dissertation readiness for defense. Evaluation is based on research originality, methodological rigor, publication activity, and compliance with doctoral academic standards.
Requirements for studies and exams	Successful completion requires continuous research progress, documented experimental and theoretical results, active participation in scientific seminars and research discussions, preparation of scientific publications, and positive evaluation by the scientific supervisor and the department. The final cumulative assessment confirms readiness for doctoral dissertation defense.
Reading list	<ol style="list-style-type: none"> 1. Creswell, J. Research Design. Sage. 2. Booth, W., Colomb, G., Williams, J. The Craft of Research. University of Chicago Press. 3. Selected peer-reviewed publications in Physical Review B, Applied Physics Letters, Nano Letters, Advanced Functional Materials, and Journal of Applied Physics. 4. International standards and guidelines for doctoral research ethics, scientific publication, and academic integrity.

Module designation	Module of final attestation
Semester(s) in which the module is taught	Spring (6)
The person responsible for the module	Baytimbetova B.A.
Language	Kazakh / Russian / English
Attitude to the curriculum	Final Attestation (FA) – Mandatory Component
Workload (including contact hours, self-study hours)	Total workload: 12 ECTS

Credits	12 ECTS
Necessary and recommended prerequisites for joining the module	Successful completion of all theoretical modules (BD and PD) within the doctoral program in Applied and Engineering Physics. Successful completion of the Experimental Research Module (RWDS – cumulative research credits as defined in the program). Fulfillment of publication requirements in accordance with national and university regulations. Approval of the doctoral dissertation by the scientific supervisor and department.
Module objectives / expected learning outcomes	The aim of the module is to assess the doctoral candidate's ability to generate original scientific knowledge and defend an independent research contribution at the international level in applied and engineering physics. Upon completion of the module, the doctoral candidate demonstrates the ability to: <ul style="list-style-type: none"> • present an original scientific contribution in applied and engineering physics; • justify the novelty, significance, and relevance of research results; • critically defend methodological approaches and experimental design; • demonstrate advanced theoretical, computational, and experimental competence; • respond to expert questions at a professional research level; • contribute new scientific knowledge that meets international academic standards
Description	The Module of Final Attestation includes the completion, submission, and public defense of the doctoral dissertation. The dissertation must represent an original, independently conducted research project contributing new scientific knowledge in applied and engineering physics. The work must meet international research standards and demonstrate methodological rigor, scientific novelty, and practical or theoretical significance. The defense is conducted before the Dissertation Council in accordance with national legislation and university regulations.
Exams and assessment formats	Assessment is conducted through the public defense of the doctoral dissertation before the Dissertation Council. Evaluation criteria include: <ul style="list-style-type: none"> • scientific novelty and originality; • theoretical and methodological depth; • quality of experimental, computational, or analytical results; • publication record in peer-reviewed journals; • practical or theoretical significance; • quality of oral defense and responses to expert questions.
Requirements for studies and exams	Admission to final attestation is granted to doctoral candidates who: <ul style="list-style-type: none"> • have completed all required credits of the doctoral program; • have fulfilled research and publication requirements;

- | | |
|--|--|
| | <ul style="list-style-type: none">• have received positive reviews from the scientific supervisor and independent reviewers;• have obtained official permission for dissertation defense. |
|--|--|