**MODULE HANDBOOK**
EP PhD 8D05301 – Physics

Aktobe, 2025

# EP PhD 8D05301 – Physics

**Content**

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| EP | 8D05308 Physics |
| Module title | **Module 1.2 - Scientific and theoretical**<br>Scientific research methods |
| Semester | 1 |
| Responsible Instructor | Sagimbayeva Shynar Zhanuzakovna Associate Professor |
| Language of Instruction | Russian |
| Correlation with the curriculum | Required component |
| Forms of Instruction | PBL, teamwork, flipped classroom |
| Student Workload (including contact hours and SWS) | Lectures – 15 hours, practical classes – 30 hours, SIWT– 25 hours, SIW – 80 hours (lecture, seminar etc.) / 150 hours |
| ECTS | 5 |
| Required and Recommended Prerequisites for Taking the Module: | Prerequisites: Science of history and philosophy; Foreign language; The basis of the organization of scientific research work. |
| Module objectives/intended learning outcomes | **Module objective:** deepening and generalization of knowledge on the origin and development of scientific and historical style; development in students of skills in structured presentation of their own ideas, the ability to create scientific and scientific informational texts of various types, taking into account the specifics of academic discourse.<br>**Learning outcomes:**<br>1. Demonstrate the presence of a significant amount of scientific knowledge, acquired systematically and reflecting the current state of physical science, its specific areas;<br>2. Be proficient in modern information technologies, including methods of studying, processing and storing scientific information;<br>3. Review scientific works, independently write monographs, textbooks, articles for international peer-reviewed journals, correctly format a dissertation;<br>4. Application of the acquired generalized knowledge related to academic writing.<br>5. Independent learning and the ability to learn from others in the course of everyday practical work, improving the skills of selecting and evaluating sources of information, searching for and analyzing literature.<br>6. Use of theoretical, methodological, reference and information materials for independent understanding and analysis of trends in the field of their scientific activity. |
| Content | During the course, students will develop the relevant competencies aimed at forming the readiness and ability to implement their own research interests and present their results in various genres of academic writing in accordance with the standards of the international scientific community. During practical classes, students will learn to distinguish and analyze different types of academic writing, independently prepare essays, scientific articles, formatting them in accordance with the requirements, thereby preparing themselves for the completion of the final qualifying work - the dissertation work (project). |
| Form of Examination | Oral exam |
| Requirements for Study and Examinations | Students who have mastered the course material and scored at least 50% of the total rating based on the results of the 1st and 2nd midterm tests are allowed to take the final exam |
| References | **Main references :**<br>1. Kvitsinia M.B. Academic writing, a tutorial, Sukhum 2018. – http / /neb.arsu.kz<br>2. Kuvshinskaya Yu.M. Academic writing from research to text, a tutorial, 2019. - http//neb.arsu.kz<br>3. Korotkina I. Academic writing, 2011 - http//neb.arsu.kz<br>4. Isenova F.K. Academic writing and reading. Astana, 2015 - http//neb.arsu.kz<br>5. Ibraeva A.G., Ippolitova T.V. Academic writing: principles of structuring and writing a scientific text. - Petropavlovsk: 2015 - http//neb.arsu.kz<br>6. Preparation and editing of a scientific text: a teaching aid / compiled by N.P. Perfileva. - 3rd ed.; reprinted - M.: Flinta, Nauka, 2016. - 111 p.<br>7. Kolesnikova, N.I. From synopsis to dissertation: a teaching aid for developing writing skills. - 9th ed.; reprinted - M.: Flinta, Nauka, 2016. - 287 p. |

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| Module title | 1.2 Scientific-Theoretical Module – Polymer Composite Materials |
| Semester | 2 |
| Responsible Instructor | Prof. Amirbek Bekeshev,<br>Cand. Phys.-Math. Sci. |
| Language of Instruction | Kazakh / Russian |
| Correlation with the curriculum | Profile discipline, elective component |
| Forms of Instruction | Lecture, practical classes, SIWT, SIW |
| Student Workload (including contact hours and SWS) | Total workload: 150 hours<br>Contact hours: 45 hours (15 lectures, 30 seminars)<br>Independent study workload: 80 hours SIW, 25 hours SIWT |
| ECTS | 5 |
| Required and Recommended Prerequisites for Taking the Module: | Materials science, General chemistry, Physics of condensed state |
| Module objectives/intended learning outcomes | Objective: deepening doctoral students' understanding of the structure, properties, and behavior of polymer composite materials, focusing on their application in high-performance technologies and scientific research.<br>Learning outcomes: Upon completion of the module, doctoral students will be able to:<br>1. Identify the main classes of polymers and copolymers and describe their synthesis techniques.<br>2. Explain the physical and mechanical behavior of polymers under varying environmental and operational conditions.<br>3. Apply theoretical knowledge to solve practical problems in polymer composite technology.<br>4. Use experimental methods to determine the structural and physicochemical characteristics of polymer systems.<br>5. Calculate and interpret key parameters of polymer composites.<br>6. Conduct critical analysis of scientific literature and formulate research questions.<br>7. Plan independent research projects, select appropriate methodologies, and identify necessary resources. |
| Content | The course covers polymer structures and classification, physicochemical properties, rheology, composite formation, interfacial interactions, environmental resistance, and experimental methods for analyzing composite materials. |
| Form of Examination | Written (essay) |
| Requirements for Study and Examinations | Regular participation in lectures and seminars<br>Completion of all assigned SIWT and SIW tasks<br>Timely submission of assignments and adherence to academic integrity<br>Demonstration of critical thinking and research skills in the assignments and the final work |
| References | 1. Baimendina, A. Polymer Composite Materials: Textbook. – Almaty: KazNRTU, 2020. – 245 p.<br>2. Zhumadilova, S. Composite Materials in Engineering: Teaching manual. – Nur-Sultan: ENU, 2019. – 170 p.<br>3. Bahitov, M. A Guide to Thermoset Composites. – Almaty: Ziyat, 2015. – 310 p.<br>4. Malhotra, S.K. Handbook of Polymer Composites for Engineers. – Woodhead Publishing, 2014.<br>5. Polymer Composites Open Access Journal – www.mdpi.com/journal/polymers<br>6. Journal of Composite Materials (SAGE) – www.journals.sagepub.com/home/jcm |

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| Module title | **Module 2.2 - Research Methods in Physics.**<br>Monte Carlo Method in Physical Research |
| Semester | 2 |

# EP PhD 8D05301 – Physics

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| Responsible Instructor | Spivak-Lavrov Igor Felixovich |
| Language of Instruction | Russian |
| Correlation with the curriculum | Major discipline, elective component |
| Forms of Instruction | Lecture, practical classes, SIWT, SIW. |
| Student Workload (including contact hours and SWS) | Total workload: 150 h<br>Contact hours: 45 h (15 h lectures, 30 h practical classes)<br>Independent study, including preparation for exams, in hours: 25 h SIWT, 80 h SIW |
| ECTS | 5 |
| Required and Recommended Prerequisites for Taking the Module: | Mathematical analysis, algebra, differential equations, general and theoretical physics course |
| Module objectives/intended learning outcomes | **Learning objective:** To give a general idea of the Monte Carlo method, its capabilities and the main element of the method - the random number generator (RNG). To define classes of problems that can be solved using the Monte Carlo method. To teach the technique of solving various characteristic problems by this method.<br>**The intended learning outcomes are:**<br>1. Know and understand the basic facts associated with the Monte Carlo method; the possibilities of using the Monte Carlo method to solve probabilistic problems and statistical problems; the principles of constructing algorithms for modelling stochastic processes.<br>2. Describe the main features of the Monte Carlo method;<br>3. Understand and be able to explain the main features of the Monte Carlo method;<br>4. Be able to apply the Monte Carlo method to the solution of physical problems, solve standard physical problems using the Monte Carlo method;<br>5. Develop and implement algorithms in selected programming languages;<br>6. Analyse and interpret the results of calculations. |
| Content | The discipline 'Monte Carlo Method in Physical Research' studies statistical methods based on random sampling to solve complex physical problems. It covers random number generation algorithms, modelling of physical processes and analysis of the obtained data. The method is applied in various fields, allowing the study of systems with large numbers of particles and complex interactions. The focus is on accuracy, reliability and computational efficiency of the methods. This discipline covers the theoretical foundations and practical applications of the method, allowing researchers to use it to model complex systems and processes. |
| Form of Examination | Traditional (ticket) |
| Requirements for Study and Examinations | - obtaining quality knowledge;<br>- fulfil the teacher's requirements specified in the syllabus;<br>- independently complete all types of work (IWST assignments, coursework, graduation theses, etc.) and submit them to the teacher on time;<br>- use reliable and trustworthy sources of information;<br>- not to provide their work for cheating other students. |
| References | 1. Sobol, I.M. The Monte Carlo Method. – Moscow: Nauka, 1968.<br>2. Gorst, G. Problem Book and Practicum in Probability Theory. – Moscow, 1969.<br>3. Gould, H., & Tobochnik, J. Computer Modeling in Physics (in 2 parts). – Moscow: Mir, 1990.<br>4. Mishchenko, A.S. The Diagrammatic Monte Carlo Method as Applied to Polaron Problems // Uspekhi Fizicheskikh Nauk, Vol. 175, No. 9, 2005, pp. 925–941.<br>5. Gnedenko, B.V. A Course in Probability Theory. – Moscow: Nauka, 1988.<br>6. Demidovich, B.P., Maron, I.A., & Shuvalova, E.Z. Numerical Methods of Analysis. – Moscow: Nauka, 1967. |

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| EP | 8D05301 - Physics |
| Module title | Variational methods in physics (in Russian) |
| Semester | 2 semester |
| Responsible Instructor | Spivak-Lavrov Igor Feliksovich, Professor |
| Language of Instruction | Russian language |
| Correlation with the curriculum | Required component |
| Forms of Instruction | PBL, CLIL, teamwork, flipped classroom, etc. |
| Student Workload (including contact hours and SWS) | Lectures – 15 hours, practical classes – 30 hours, SIWT– 25 hours, SIW – 80 hours (lecture, lesson, labworks, project, seminar etc.) / 150 hours |
| ECTS | 5 |
| Required and Recommended Prerequisites for Taking the Module: | Prerequisites: probability theory, mathematical analysis, algebra, differential equations and calculus of variations, general and theoretical physics course. |
| Module objectives/intended learning outcomes | **Module objective:**<br>To give a general idea of the variational method and its possibilities and about the main elements of the method – functionality and variation. Identify classes of problems that can be solved using the variational method. To teach techniques for solving various characteristic problems using this method.<br>**Learning outcomes:**<br>1. Know and understand the basic facts related to the variational method;<br>2. Describe the main features of the variational method;<br>3. Understand and be able to explain the main features of the variational method;<br>4. Be able to apply the variational method to solve physical problems;<br>5. Be able to solve standard physical problems using the variational method.<br>6. Know the possibilities of using the variational method to solve physical problems; |
| Content | The calculus of variations is widely used in theoretical physics. Fermat's principle (the principle of least time) in geometric optics is widely known. A wide variety of physical theories can be built on the basis of the well-known variational principle of the "Principle of Least Action" formulated by Lagrange (1736-1813). |
| Form of Examination | oral exam |
| Requirements for Study and Examinations | Students who have mastered the course material and scored at least 50% of the total rating based on the results of the 1st and 2nd midterm tests are allowed to take the final exam |
| References | **Main references:**<br>1. Landau L.D., Lifshits E.M. (1972). Course of theoretical Physics, Vol. 1 – Mechanics. The Franklin Book Company.<br>2. Matveev A.N. Electrodynamics and theory of relativity: Textbook. The manual - M.: Higher School, 1986. - 415 p.<br>3. Jackson J. Classical Electrodynamics. Moscow: Nauka Publ., 1975. 559 p.<br>4. Tamm I.E. – Fundamentals of the theory of electricity. Moscow: Nauka, 1989. 576 p<br>5. Landau L.D., Lifshits E.M. Field theory. Moscow: Nauka, 1973. 460 p.<br>6. Landau L.D., Lifshits E.M. Electrodynamics of continuous media, Moscow: Nauka Publ., 1982, 620 p.<br>7. Feynman R., Leighton R., Sands M. Feynman lectures on physics. vol. 5, 6, 7 - Moscow: Mir, 1966.<br>8. Gould H., Tobochnik Ya. Computer modeling in physics (in 2 parts). Part two. - M., Mir Publ., 1990. – 390 p. |