Research School of Engineering

Department of Food Technology

The program of the entrance exams to PhD-doctoral studies in the group of educational programs D111 Food production

Semey – 2026

1 DEVELOPED

Compilers:

B. Assenova, Professor, c.t.s. _____ «27» 02 2026

B. Kulushtayeva, PhD _____ «27» 02 2026

2 DISCUSSED

At the meeting of the department of Food Technology

Protocol № 7/4 «27» 02 2026

Head of the Department _____ «27» 02 2026 G. Nurymkhan
(signature)

3 AGREED

Head of the CTCSP _____ «02» 03 2026 S. Kassymov
(signature)

4 APPROVED

Member of the Management Board –
Vice- Rector for Science _____ «02» 03 2026 Zh. Kalibekkyzy
(signature)

1. Introduction

The program of the entrance exam in a special discipline of doctoral studies is formed in the scope of the program of the previous stage of higher education (master's degree).

The main requirements for the level of training of specialists in the group of educational programs D111 Food production.

Applicants for doctoral studies must

have an idea:

– on the methods of collecting and analyzing scientific information;

– to know the methodology of teaching special disciplines, pedagogy and psychology of higher education;

– to know the methodology and methods of scientific research, the means of research and processing of their results;

to be competent in:

– the field of labor legislation;

– personnel selection and placement;

– the development of advanced industry technologies;

– conducting economic analysis of enterprise activities.

to possess skills:

– pedagogical and research activities;

– development of research plans and conducting bibliographic work using modern information technologies;

– selection of appropriate research methods, modification of existing methods, and development of new methods in accordance with the objectives of a specific study;

– processing and interpretation of obtained results with consideration of existing literature data;

– summarizing completed work in the form of reports, essays, and scientific articles prepared in accordance with established requirements, using modern editing and publishing tools;

– application of specialized terminology and effective use of personal computers to solve professional tasks.

The doctoral entrance exam is conducted in written or computer format in accordance with the Model Regulations for admission to studies in educational organization, implementing educational programs of technical and vocational education, approved by the Order of the Minister of Education and Science of the Republic of Kazakhstan of October 31, 2018 № 600.

2. The name of the discipline and its main sections

Discipline: Resource-Saving and Green Skills Technologies in Food Engineering

This discipline examines modern "green" technologies aimed at the efficient use of resources, reduction of environmental impact, and implementation of sustainable development principles in the food industry and agro-industrial complex. The course covers energy and resource efficiency, environmentally safe production, waste-free technologies, as well as the development of Green Skills competencies. Students acquire knowledge on applying innovative ecological solutions in the production, processing, storage, and packaging of food products.

Topic 1. Concept of Green Technologies

Green technologies are a set of technological solutions aimed at reducing anthropogenic environmental impact, rational use of natural resources, and ensuring sustainable development. This concept is closely related to the "green economy." The lecture examines the main principles of green technologies: resource conservation, energy efficiency, waste-free production, environmental protection, and social responsibility. Differences and advantages compared to traditional technologies are also analyzed.

Topic 2. Implementation of Green Skills in Kazakhstan

Green skills represent a set of professional competencies that ensure environmental responsibility, efficient resource use, and sustainable production. In Kazakhstan, this direction is being integrated into the education system within the framework of the transition to a green economy. The lecture discusses state programs, workforce training systems, the role of higher education institutions, and features of industrial application.

Topic 3. Main Directions of Green Technologies

The main directions include energy and resource efficiency, environmental safety, pollution reduction, life cycle management, and biomimetic engineering solutions. The lecture analyzes the Life Cycle Assessment (LCA) method, energy-efficient technologies, and environmental management systems.

Topic 4. Green Technologies in the Food Industry

In the food industry, green technologies are implemented through full utilization of raw materials, waste reduction, and conservation of water and energy. The lecture covers waste-free production, recycling, energy-efficient equipment, and environmental management systems (ISO 14001).

Topic 5. Green Technologies in Agriculture

This topic examines soil conservation technologies (no-till, minimum tillage), the use of biofertilizers, biological plant protection, land reclamation, and optimization of agroecosystems. It also includes the processing of agricultural waste and sustainable agricultural technologies.

Topic 6. Supercritical and Subcritical CO_2 Processing

Supercritical CO_2 is a unique state possessing properties of both gas and liquid. This technology is widely used in extraction, sterilization, and purification processes. The lecture discusses its physicochemical properties, advantages (absence of toxic solvents, environmental safety), and applications in the food industry.

Topic 7. Environmentally Friendly Separation Technologies

Extraction using supercritical CO_2 and subcritical water is environmentally friendly. These methods offer high selectivity, safety, and preservation of product quality. The lecture examines extraction mechanisms and areas of application.

Topic 8. Electrodialysis in the Food Industry

Electrodialysis is a process of ion separation through selective membranes. It is used for desalination, whey processing, and product quality improvement. The lecture covers its operating principles, structure, and efficiency.

Topic 9. Processing Using Enzymes

Enzymes are biocatalysts widely used in food production. The lecture discusses enzyme types (amylases, proteases, lipases), their mechanisms of action, and their impact on product quality.

Topic 10. New Technologies of Microbiological Control

Modern methods include PCR, enzyme-linked immunosorbent assay (ELISA), and biosensors. These technologies enable rapid and accurate detection of microorganisms. Their advantages and role in ensuring food safety are analyzed.

Topic 11. Green Technologies in Dehydration

Modern drying methods (vacuum, infrared, freeze-drying) allow energy savings while preserving product quality. The lecture examines the features and efficiency of each method.

Topic 12. Eco-Friendly Packaging in the Food Industry

Eco-friendly packaging is made from recyclable or biodegradable materials. The lecture discusses types of packaging, their properties, and environmental impact.

Topic 13. Green Technologies in Processing and Consumer Perception

The implementation of green technologies influences consumer trust and product demand. The lecture analyzes consumer behavior, environmental marketing, and perception factors.

Topic 14. Biodiversity and Sustainable Nutrition

Biodiversity is a key factor in ensuring food security. The lecture examines its impact on production and processing, as well as principles of sustainable nutrition.

Topic 15. Sustainable Food Systems

Sustainable food systems are balanced from environmental, economic, and social perspectives. The lecture discusses their structure, indicators, and evaluation methods.

Discipline: Design and Planning of Experiments

The discipline «Design and Planning of Experiments» is aimed at mastering methods for the proper organization, planning, and statistical processing of experimental data to ensure effective scientific research. Within this course, students study types of experiments, factor selection and management, development of mathematical models, as well as methods for analyzing research results and assessing their reliability.

The main objective of the discipline is to develop skills for the optimal organization of experimental research in scientific and industrial processes and to teach a data-driven approach to decision-making.

Topic 1. Concept of Experiment

An experiment is one of the fundamental methods of scientific research, involving the study and observation of phenomena under specially organized conditions. Its key feature is the active involvement of the researcher and the ability to control influencing factors. The main objectives of an experiment are to identify cause-and-effect relationships, test hypotheses, and obtain new scientific results. The basic principles include reproducibility, accuracy, objectivity, and control.

Topic 2. Classification of Experimental Research Types

Experiments are classified according to different criteria: by conditions of implementation (laboratory, industrial), by level of control (active, passive), and by purpose (exploratory, confirmatory, optimization). Laboratory experiments are conducted under fully controlled conditions, while industrial experiments take place in real technological environments. In active experiments, factors are deliberately changed, whereas in passive experiments, only observation is performed.

Topic 3. Random Variables and Their Distribution Parameters

Random variables are quantities whose values are uncertain and follow probabilistic laws. They are divided into discrete and continuous types. Key parameters describing them include expected value, variance, and standard deviation. Probability distributions such as normal, binomial, and Poisson play an important role in analyzing experimental results.

Topic 4. Statistical Criteria and Their Application

Statistical criteria are used for hypothesis testing. The concepts of null hypothesis (H_0) and alternative hypothesis (H_1) are considered. The main statistical tests include Student's t-test, Fisher's F-test, and Pearson's χ^2-test. These methods allow assessment of data reliability and evaluation of factor significance.

Topic 5. Fundamentals of Analysis of Variance

Analysis of variance (ANOVA) is used to evaluate the influence of multiple factors. This method decomposes total variability into factorial and random components. It includes one-way and multi-factor analysis. ANOVA helps identify the most significant factors in industrial processes.

Topic 6. Correlation and Regression Analysis

Correlation describes the relationship between variables, and the correlation coefficient measures its strength. Regression analysis determines functional dependencies between variables. Linear and multiple regression models are widely used for predictive modeling.

Topic 7. Full and Fractional Factorial Experiments

Factorial experiments allow the study of the simultaneous influence of multiple factors. In a full factorial experiment, all possible combinations are considered, whereas in a fractional factorial design, only a subset is used. These approaches help save resources and improve experimental efficiency.

Topic 8. Optmization (Extreme) Experimental Design

The purpose of extreme experimental design is to determine optimal conditions (maximum or minimum) of a process. Methods such as gradient and ascent approaches are applied. These experiments are essential for optimizing technological parameters.

Topic 9. Mathematical Modeling Based on Full Factorial Design

Mathematical models are constructed based on experimental results, describing the relationship between factors and responses. Such models enable process prediction and control, improving system efficiency.

Topic 10. Regression Modeling of Passive Experiments

In passive experiments, regression models are developed based on observed data without direct manipulation of factors. This approach is used to describe real industrial conditions and system behavior.

Topic 11. Expert Analysis: Preference Method and Pairwise Comparison Method

Expert methods allow qualitative assessments to be expressed quantitatively. The preference method is based on comparing alternatives, while the pairwise comparison method is widely used in decision-making processes.

Topic 12. Objectives and Features of First-Order Designs

First-order experimental designs are used to construct linear models. They are simple and applied in the initial stages of research. These designs help identify main factor effects.

Topic 13. Objectives and Features of Second-Order Designs

Second-order designs enable the construction of quadratic models that describe complex system behavior. Central composite and Box–Behnken designs are among the most commonly used approaches.

Topic 14. Implementation of Experimental Design and Experimental Errors

During experimentation, systematic and random errors may occur. Systematic errors arise from instrument inaccuracies, while random errors result from external factors. Techniques such as replication, calibration, and standardization are used to minimize errors.

Topic 15. Processing of Experimental Results

Experimental data are processed using statistical methods. Mean values, variance, and confidence intervals are calculated. Results are presented in tables and graphs, followed by scientifically justified conclusions.

Discipline: Modern Methods of Food Raw Materials and Product Analysis

This course is aimed at mastering modern analytical methods used to assess the quality, safety, and nutritional value of food raw materials and finished products. The discipline covers chemical, physical, biochemical, and instrumental methods of food analysis, as well as their practical applications.

Students acquire skills in using modern laboratory equipment and techniques (chromatography, mass spectrometry, spectrophotometry, etc.) to identify key components in food products, analyze harmful contaminants (heavy metals, pesticides, adulterants), and evaluate the content of vitamins and minerals. In addition, organoleptic and sensory evaluation methods, biotechnological analysis features, and quality control systems are studied.

Topic 1. Introduction to Modern Food Analysis Methods: Course Objectives and Tasks

This topic covers the objectives and tasks of the discipline. The importance of food product analysis in ensuring quality and safety is explained. The development of modern analytical methods, their applications in the food industry, and the fundamental principles of laboratory analysis are described.

Topic 2. Qualitative and Quantitative Analysis of Food Raw Materials and Finished Products

Methods of qualitative and quantitative analysis of food products are considered. Qualitative analysis focuses on identifying substances in a sample, while quantitative analysis determines their amounts. Approaches for assessing the safety and compliance of food raw materials and finished products are explained.

Topic 3. Fundamentals of Chemical Analysis and Main Components of Food Products

Methods for studying the chemical composition of food products are discussed. The main components include water, proteins, fats, carbohydrates, minerals, and vitamins. Theoretical principles of chemical reactions, titrimetric, and gravimetric methods are explained.

Topic 4. Chromatographic Methods: Theory and Practice of HPLC and GC

The fundamentals of chromatography and the principles of substance separation are considered. The working principles, application areas, and importance of high-performance liquid chromatography (HPLC) and gas chromatography (GC) in food analysis are explained.

Topic 5. Mass Spectrometry and Its Capabilities in Food Compound Identification

The theory and principles of mass spectrometry are discussed. This method enables the identification of compounds in complex mixtures. Its importance in detecting harmful and beneficial substances in food products is emphasized.

Topic 6. Physical Analysis Methods: Texture, Density, and Moisture Content

Methods for determining the physical properties of food products are described. Techniques for measuring texture (hardness, elasticity), density, and moisture content are explained. The impact of these parameters on product quality is analyzed.

Topic 7. Sensory Analysis: Organoleptic Methods and Tasting Evaluation

Organoleptic evaluation methods are considered. Techniques for assessing taste, smell, color, and texture are explained. The organization of tasting panels, evaluation scales, and data processing methods are described.

Topic 8. Biotechnological Methods and Analysis of GMO Products

The role of biotechnological methods in food analysis is discussed. Methods for detecting genetically modified organisms (GMOs) and the principles of polymerase chain reaction (PCR) are explained.

Topic 9. Methods for Detecting Pesticides and Heavy Metals in Food

Methods for identifying harmful substances in food products are considered. Techniques for detecting pesticides and heavy metals (lead, cadmium, mercury) and their impact on human health are explained.

Topic 10. Quantitative Determination of Vitamins and Minerals

Methods for analyzing vitamins and minerals in food products are discussed. Spectrophotometry, atomic absorption methods, and other modern analytical techniques are described.

Topic 11. Determination of Fat, Protein, and Carbohydrate Content in Food Products

Methods for determining the main nutrients are explained. Proteins are analyzed using the Kjeldahl method, fats through extraction methods, and carbohydrates through chemical and enzymatic techniques.

Topic 12. Methods for Detecting Food Adulteration

Methods for identifying food fraud are considered. Types of adulteration (qualitative, quantitative, and substitution-based) and approaches for their detection are explained. The role of modern analytical techniques in ensuring authenticity is highlighted.

Discipline: Modern Technologies of Processing Vegetables, Fruits, and Grain Crops

This course studies modern technologies for processing vegetables, fruits, and grain crops, their scientific foundations, and industrial features. The discipline covers the chemical composition and nutritional value of plant raw materials, methods of storage and processing, as well as technologies for producing finished food products.

Students master key technological processes such as the production of juices, purees, jams, preserves, canned foods, dried and frozen products, as well as flour and cereal production. In addition, the course addresses the preservation and enrichment of biologically active substances, the production of functional foods, and the application of innovative and energy-saving technologies.

Topic 1. Scientific Foundations of Processing Technology for Vegetables, Fruits, and Grain Crops

This topic examines the physicochemical, biochemical, and microbiological principles of plant raw material processing. Enzymatic reactions, moisture exchange, heat transfer, and mass transfer processes occurring during processing are analyzed. The general principles of technological processes and their impact on product quality are explained.

Topic 2. Chemical Composition and Nutritional Value of Vegetable and Fruit Raw Materials

The composition of vegetables and fruits, including water, carbohydrates, organic acids, vitamins, minerals, and biologically active compounds, is studied. Their impact on human health and nutritional value is analyzed. Differences between various types of raw materials are compared.

Topic 3. Primary Mechanical Processing of Vegetable and Fruit Raw Materials

This topic covers primary processing stages such as washing, cleaning, sorting, and grinding. The technological importance of these processes, the equipment used, and their impact on product quality are explained.

Topic 4. Morphological and Chemical Characteristics of Grain Crops

The structure of grain crops (bran, endosperm, embryo) and their chemical composition (proteins, starch, fats) are studied. The technological properties of different grain types are compared.

Topic 5. Methods for Preserving and Enriching Biologically Active Substances in Plant Raw Materials

Methods for preserving vitamins and other bioactive compounds during processing are considered. Techniques such as drying, low-temperature storage, the use of antioxidants, and enrichment methods are described.

Topic 6. Storage of Fruits and Vegetables and Pre-Storage Treatment Methods

Storage methods (cooling, controlled atmosphere storage) and pre-treatment techniques (blanching, disinfection) are examined. The main purpose is to maintain product quality for an extended period.

Topic 7. Modern Technologies for Fruit and Vegetable Juice Production

The main stages of juice production include raw material preparation, pressing, filtration, pasteurization, and packaging. Modern technologies such as aseptic packaging and membrane filtration are analyzed.

Topic 8. Technology for Producing Purees, Jams, Preserves, and Marmalade

This topic covers raw material processing, sugar addition, boiling, and gel formation processes. Mechanisms of thickening and texture formation are explained.

Topic 9. Technological Features of Vegetable and Fruit Canning

Canning methods such as sterilization and pasteurization and their role in ensuring microbiological safety are studied. Hermetic packaging and storage conditions are described.

Topic 10. Technologies for Drying and Freezing Fruits and Vegetables

Drying and freezing methods aimed at extending shelf life are analyzed. Different drying techniques and freezing technologies, along with their advantages and disadvantages, are considered.

Topic 11. Vacuum and Freeze-Drying Methods

The principles and technological features of vacuum drying and freeze-drying (lyophilization) are discussed. Their role in producing high-quality products is emphasized.

Topic 12. Grain Processing into Flour and Cereal Products

Processes such as cleaning, conditioning, milling, and sieving of grains are examined. The main stages of flour and cereal production are described.

Topic 13. Technologies of Functional and Dietary Products from Grain Crops

The characteristics of functional foods, biologically active components added to their composition, and their health benefits are studied.

Topic 14. Innovative and Energy-Saving Technologies

Modern technologies such as membrane processes, microwave processing, and infrared drying are analyzed. Energy-efficient solutions and principles of waste-free production are considered.

Topic 15. Principles of Product Quality Assessment and Standardization

Quality indicators such as organoleptic, physicochemical, and microbiological parameters are examined. The role of standards and regulatory documents (GOST, ISO) is explained.

Discipline: Artificial Food Products Technology

This discipline examines the scientific foundations, technologies, and development trends of producing artificial and alternative food products. The course covers cellular agriculture, plant- and animal-based analogs, fermentation technologies, genetically modified organisms (GMOs), bioreactor systems, and modern digital technologies, including artificial intelligence, used in food product design.

Topic 1. Introduction to Artificial Food Technology

Artificial food technology is a modern scientific and technological field aimed at producing alternative food products to reduce dependence on traditional agriculture. This field includes plant-based products, cellular agriculture products, fermented foods, and laboratory-grown food items. Its main objective is to ensure safe, high-quality, and environmentally sustainable food supply. Artificial food technology focuses on resource efficiency, increased production effectiveness, and reduced environmental impact.

Topic 2. Historical Development of Artificial Food Products

The history of artificial food production dates back to the mid-20th century. Initially, it was limited to scientific research; however, today it has reached an industrial scale. Since the 2000s, plant-based meat alternatives and cultured meat production have significantly developed. Currently, numerous international companies are actively involved in this field, offering innovative products. Scientific progress in biotechnology, genetic engineering, and food engineering has driven this development.

Topic 3. Cell Cultivation: Principles and Methods

Cell cultivation is a technology for producing food products by growing cells extracted from living organisms under in vitro conditions. Cells are cultivated in bioreactors using a controlled nutrient medium. Key principles include sterile conditions, controlled temperature, pH, and nutrient supply. This process enables the production of meat, fat, and other food components.

Topic 4. Plant-Based Meat Analogs: Innovations and Challenges

Plant-based meat alternatives are produced from soy, pea, and wheat proteins. Their main goal is to replicate the taste and texture of animal meat. Technological challenges include texture formation, flavor enhancement, and consistency stabilization. Consumer acceptance is also a critical factor in market success.

Topic 5. Genetic Modification of Organisms in the Food Industry

Genetic modification (GMO) refers to altering the genetic structure of organisms to improve their characteristics. In food production, GMOs are used to increase yield,

enhance pest resistance, and improve nutritional value. Safety concerns are regulated through international standards.

Topic 6. Fermentation as a Basis for Novel Foods

Fermentation is the process of transforming organic substances using microorganisms. This technology is used to produce products such as yogurt, cheese, and kvass. Additionally, probiotic foods have beneficial effects on the digestive system. Fermentation also extends product shelf life.

Topic 7. Bioreactors and Nutrient Media in Cellular Agriculture

Bioreactors are specialized systems used for cell cultivation. They allow precise control of temperature, gas exchange, and nutrient composition. Nutrient media typically include amino acids, vitamins, and minerals. Scaling up production remains a key challenge in this field.

Topic 8. Artificial Intelligence in Food Formula Design

Artificial intelligence is used to optimize food formulation. Machine learning algorithms analyze ingredient combinations, flavor properties, and nutritional value. This approach enables faster and more efficient development of new food products.

Topic 9. Environmental Advantages of Artificial Food Products

Artificial food production requires fewer natural resources, reduces water and land usage, and lowers greenhouse gas emissions. It aligns with sustainable development goals and promotes environmentally friendly production models.

Topic 10. Ethics and Public Acceptance of Artificial Foods

Ethical issues related to artificial foods include consumer trust, perceptions of naturalness, and cultural factors. Public opinions vary widely, making education and awareness essential for acceptance.

Topic 11. 3D Food Printing Technology

3D food printing is a layer-by-layer food fabrication technology. It enables the creation of products tailored to individual dietary needs. Raw materials are typically used in paste or gel form.

Topic 12. Food Safety and Standardization

The safety of artificial food products is regulated by international standards. The HACCP system ensures hazard control in production processes. ISO standards guarantee product quality and compliance.

Topic 13. Economics of Artificial Food Production

Artificial food production is an investment-attractive sector with rapidly growing market potential. Economic efficiency is driven by resource savings and production automation.

Topic 14. Hybrid Technologies: Combination of Plant and Cellular Components

Hybrid technologies integrate plant-based and cellular components to create new food products. These products exhibit improved taste, texture, and nutritional value.

Topic 15. The Future of the Food Industry: Global Trends

Key trends in the food industry include artificial intelligence, automation, sustainable production, functional foods, and personalized nutrition. Artificial food production is expected to play a significant role in the future.

Discipline: Research Methodology

This discipline covers the principles of organizing, planning, and conducting scientific research, as well as the theoretical and practical foundations of scientific work. It includes the methodology of scientific cognition, research stages, experimental design principles, data analysis, statistical processing, and mathematical modeling techniques.

In addition, the course addresses scientific ethics, methods for ensuring the reliability and validity of research results, planning of scientific projects, and preparation of master's theses. It is aimed at developing students' competencies required for independent research activities.

Topic 1. Science and Scientific Research Methods

Science is a systematic field of knowledge that studies the laws of nature, society, and thinking. Scientific research methods include observation, experiment, analysis, synthesis, induction, and deduction. These methods serve as the primary tools for acquiring scientific knowledge.

Topic 2. Scientific Research

Scientific research is a systematic process aimed at acquiring new knowledge or refining existing knowledge. It is carried out based on a clearly defined goal, objectives, and hypothesis.

Topic 3. Stages of Scientific Research Work

Scientific research consists of the following stages: topic selection, literature review, definition of goals and objectives, selection of research methods, conducting experiments, data processing, and drawing conclusions.

Topic 4. Methodology of Scientific Research

Methodology is a system of principles and approaches of scientific cognition. It determines the logic of research, the selection of methods, and the interpretation of results.

Topic 5. Theoretical and Experimental Research

Theoretical research focuses on the development of models and hypotheses, whereas experimental research is based on data obtained through practical experiments. Both approaches are interrelated.

Topic 6. General Information on Experimental Research

Experimental research is a set of experiments conducted under controlled conditions. Its purpose is to identify relationships between phenomena and to verify theoretical assumptions.

Topic 7. Advanced Scientific Practice

Advanced practice refers to methods and technologies proven effective in science and industry. It serves as a foundation for the development of new research.

Topic 8. Preparatory Stage of Scientific Research Work

At this stage, the research topic is selected, literature is reviewed, a hypothesis is formulated, and a research plan is developed.

Topic 9. Methodology of Planning Scientific Research

Planning involves defining the research structure, dividing it into stages, and ensuring efficient use of resources. The plan must be clear, systematic, and measurable.

Topic 10. Statistical Data Analysis and Scientific Data Management

Data collection, processing, and analysis are carried out using statistical methods. Indicators such as mean value, variance, and correlation are used. Data management ensures its storage and accessibility.

Topic 11. Error Reduction Strategies: Randomization, Blocking, and Validation

Randomization reduces errors through random selection. Blocking is used to separate the influence of factors. Validation is a method for confirming the accuracy of obtained results.

Topic 12. Factorial Experimental Design

Factorial design allows the simultaneous study of multiple factors. This method helps identify interactions between variables.

Topic 13. Fundamental Principles of Scientific Ethics

Scientific ethics includes honesty, objectivity, rejection of plagiarism, data integrity, and respect for intellectual property rights.

Topic 14. Mathematical Modeling and Optimization of Technological Processes

Mathematical modeling describes research objects using equations. Optimization involves determining the most effective technological parameters.

Topic 15. Methodology for Preparing a Master's Thesis

A master's thesis is the final scientific research work. It consists of an introduction, literature review, methodology, results, analysis, and conclusion. The work must be formatted in accordance with academic requirements.

3. List of recommended literature

The Basic s literature s

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