EDUCATIONAL COMPONENT "CERTIFICATION"

**Requirements
to the mandatory minimum content of theses
master's degree in specialty 113 "Applied mathematics"
Educational and Professional Program "Computer and Mathematical Modeling"**

The educational component "Certification" is implemented in the form of a master's qualification (diploma) thesis.

A master's qualification (diploma) work is a work that represents an independent theoretical and applied research at the final stage of a higher education student's education and is one of the forms of revealing theoretical and practical knowledge, the ability to apply them in solving specific tasks.

The thesis demonstrates the author's ability to use acquired competencies and learning outcomes. The result of the defense of the diploma thesis must demonstrate the acquisition **of integral competence:** *"The ability to solve problems of a research and/or innovative nature in the field of applied mathematics".*

The educational component "Certification", in addition to integral competence, is especially focused on the acquisition of individual general and special (professional) competencies and learning outcomes defined by the educational program.

Competencies:

GC3. Ability to master modern knowledge, formulate and solve problems.

GC5. Ability to conduct professional activities, in particular in the international environment.

GC7. Ability to think abstractly, analyse and synthesise.

PC1. Ability to solve tasks and problems that can be formalised, require updating and integrating knowledge, in particular in conditions of incomplete information.

PC2. Ability to conduct scientific research aimed to develop new and adapt existing mathematical and computer models to study various processes, phenomena and systems, conduct appropriate experiments and analyse the results.

PC4. Ability to develop and research mathematical and computer models, conduct computational experiments and solve formalised problems using specialised software.

PC9. The ability to mathematically formalise the formulation of scientific and practical problems, to choose a mathematical analytical or numerical method of its solution, which ensures the required accuracy and reliability of the result.

PC12. Ability to identify the essence of scientific and technical problems in professional activities, to apply appropriate mathematical models for the study of mechanical objects and processes.

Learning outcomes:

LO2. Collect, systematize and analyse scientific and technical information on professional activities.

LO3. Logically, consistently and accurately formulate their thoughts and present information in professional communication, apply information and technical means and pedagogical methods to present the results of scientific, applied and IT projects.

LO11. Possess skills of abstract thinking, analysis and synthesis.

LO13. Have knowledge in preparing scientific and technical reports on completed design or research work and in implementing the results of research and development.

LO18. Understand the essence of scientific and technical problems in professional activity, apply appropriate mathematical models for the study of mechanical objects and processes.

The qualification work undergoes attestation to confirm that the competences and learning outcomes acquired by the applicants meet the requirements of the content of the educational program. Attestation takes place through public defense of qualification work. The student must present his views on the topic of research in a logically coherent and scientifically grounded manner, draw conclusions and formulate proposals or recommendations regarding the solved problem.

In its essence, the master's degree thesis on the specialty 113 - Applied Mathematics, educational and professional program "Computer and Mathematical Modeling" is **an independently conducted research, which is based on the development of a mathematical model of an object or process. To carry out calculations based on the developed model, you can use your own software, or use well known design and analysis software complexes (i.e. Ansys). An additional advantage is the development of our own software that implements the developed mathematical models.**

The choice of methods of building mathematical models, as well as software complexes, is not limited by specific technological frameworks, approaches or programming languages.

Thesis, which claims to grade excellent or very good (A-B) must have a high level of algorithmic and/or mathematical complexity. It is mandatory to carry out **elements of research** aimed at the subject area with the use of developed solutions.

The text of the work must be written in one's own hand. Works based on which the facts of textual borrowings have been established are not allowed. Text borrowing without proper references of the results obtained by other authors, distortion or falsification of results is not allowed. The use of methods, technical solutions, results obtained by other authors as auxiliary or source data in the thesis must be accompanied by mandatory references to original works. The main part of the thesis before submission to the defense is submitted for automatic plagiarism check through the system that is official at NTU «KhPI». **Establishing the fact of violation of academic integrity is the basis for not being admitted to the defense or annulment of the decision of the commission and annulment of the diploma.**

Evaluation of the thesis (final certification) is carried out by the State Examination Commission (SEC) based on the results of the public defense.

Guarantor of the educational and
professional program (1 year 4 months)   Oleksiy LARIN

Head of the MME Department   Oleksii VODKA

The thesis must necessarily consist of structural parts filled with content in accordance with the requirements listed in Table.

No	Tentative title of the section	Content requirements	Estimated volume
1	**Introduction**	Introduces a practical problem to the subject area, which is solved in the thesis. Justifies the relevance of the chosen topic from the point of view of applied mathematics (in the context of technological motivation to solve the problem set in the thesis). Contains the formulation of the purpose of the work, object and subject of research.	0.75-2 pages
2	**Literary review**	Studying scientific and technical literature and writing a literature review is an important stage of the thesis. When writing a literature review, you need to analyze at least 20-40 sources of information; as such can appear: textbooks, monographs, articles in scientific journals, websites, technical reports, etc. In the literature review, it is recommended to describe: the main stages of the history of research on problems on the topic of the thesis; existing main methods and approaches to solving the task, their advantages and disadvantages; justification of the chosen approaches to problem solving on the topic of the thesis. When describing the relevance and main problems of solving the task, it is necessary to use the authors' works published **in the last 5 years**. To describe the main stages of the history of research, it is necessary to examine the main works published during the last 10-15 years. Based on the description of the main research on the subject of the thesis, a generalization is made and the existing main methods and approaches to solving the problem are revealed. The next step should be to choose either already existing mathematical models or justify the need to develop new approaches. When describing the content of the works in the literature review, the following sequence should be observed: - indicate the time of publication (for example: the 90s), the author's last name and, in square brackets, the number of the source of information according to the list; - briefly describe the main ideas proposed by the author in the work; - indicate the advantages and disadvantages of the approach developed by the author.	7-15 pages

		For a better description of the main ideas of the author, it is allowed to cite the main formulas from the work.	
3	**Formulation of the problem**	At the beginning, this section should repeat the formulation of the goal of the work and provide the content of the tasks that will ensure the achievement of this goal. The section provides the raw data (drawings, material specifications, load parameters, parameters to be defined, etc.).	1-3 pages
4	**Justification of the choice of models, technological solutions**	The section should contain a description that includes: justification of the choice of modeling tools, software implementation, hardware (if necessary). A descriptive analysis of existing technologies and/or technological applications, software complexes used in the thesis should be presented. The description must be accompanied by a reference to information sources (books, websites, scientific articles, etc.). *The section can be combined with a literature review*	5-10 pages
5	**Methods and algorithms for solving diploma problems** *(the name must be specified according to the topic of the work)*	The section provides theoretical information on mathematical models, numerical methods of their solution. Algorithmic details of methods and approaches should be given. This section **is not an overview,** but is a description of the theoretical foundations on which the solution of the main problems of the thesis is based, however, references to literary sources are mandatory. When formulating a mathematical model, it is necessary to state all the simplifications that were used. This section ends with the formulation of appropriate mathematical problems for the development of computer methods and calculation algorithms. *In fact, this section is a theoretical statement of problems that are solved in the thesis and is a mandatory part that ensures the demonstration of the student's acquisition of professional theoretical competencies.*	5-10 pages

Sections 4 and 5 can be combined into one with the consent of the supervisor of the thesis, although in essence these sections have significantly different contents:
The 4th section is descriptive and aims to provide justification for the choice of technologies and approaches used on the basis of comparative analysis and/or analysis of results presented in the literature and by other authors;
The 5th section already presents the theoretical principles that are the basis for solving the set problems; it is extremely important that the theoretical information is not presented in a general form, but acquire specifics and correspond directly to the topic of the thesis and its tasks.

6	**Problem solving method** *(The title must be specified according to the*	In this section, a mathematical description of computer methods for solving the mathematical problem formulated in the previous section is taught or developed. In the case of using standard finite-element packages of calculation programs, it is necessary to describe the main provisions of the finite-element technology and focus on those stages of mathematical modeling that require	5-10 pages

		justification from the point of view of accuracy and probability when using mesh modeling methods, to indicate specific steps that must be taken to obtain decision. If your own software is used (tasks related to artificial intelligence, computer, etc.), then this section provides algorithms, block diagrams, program screenshots, database schemes. The text of developed programs and macro programs for standard finite-element packages is issued as appendices.	
7	**Testing and error estimation** *(The title must be specified according to the topic of the diploma)*	The explanatory note to the thesis must present the results of modeling (use of developed models). It is necessary to submit an analysis of errors, convergence of numerical methods, to present the results of the validation procedures of model parameters, methods and algorithms.	3-5 pages
8	**Analysis of results** *(the title must be specified according to the topic of the diploma)*	This section presents the results of the diploma work from the point of view of achieving the set tasks and meeting the functional requirements that are laid down in the section «Statement of the task». A large number of screenshots is not welcomed. Instead of set of screenshots, there are a text description with an analysis of each result, evaluations and recommendations. It is desirable to present their generalization (graphically, tabularly) in addition to a simple demonstration. *This section can be combined with section 7. However, the content of these sections should not be confused. One section shows examples of application and analysis of results, and the previous one provides a check for correctness (testing).*	3-5 pages
9	**Conclusions**	The results of the work carried out are briefly presented. They must give a clear answer to the question of whether the goal that was formulated in the introduction was achieved, how the research problems were solved (it is important that the conclusions indicate WHAT problems were solved, HOW they were solved and what was obtained as a result). Recommendations for the practical use of the obtained results are presented in the conclusions.	1-2 pages
10	**List of sources of information**	The student is obliged to refer to the sources from which materials, individual results or ideas were used in the thesis for the development of own problems, tasks, questions. You should refer to modern editions (5-10 years for scientific sources, Internet links; 10-15 years for classic textbooks, books). To simplify the design of the list of references, it is recommended to use specialized software tools: Mendeley, EndNote, Zotero. It is not possible to include in the bibliographic list works that are not referenced in the text of the thesis and were not actually used. **The number of sources used is 20-40 names** for the diploma thesis **based on the topic** of the work (not including the names used in the sections of the economic justification of labor).	2-5 pages