MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

National Aerospace University named by M. Ye. Zhukovsky
"Kharkiv Aviation Institute"

Department of Information Technologies of Design No. 105

APPROVED BY

Guarantor of the educational program

_____ Daniil REVENKO

«30» August 2024

SYLLABUS OF THE MANDATORY EDUCATIONAL COMPONENT

Processing and Analysis of Research Results Using IT

Field of Knowledge: 05 Social and Behavioral Sciences

Specialty: 051 Economics

Educational Program: Economics

Higher Education Level: Third (Educational and Scientific)

Mode of Study: Full-time and Part-time

The syllabus is effective from 01.09.2024

Kharkiv – 2024

Developed by: Oleksandr KARATANOV, PhD in Technical Sciences, Associate Professor, Department of Information Technologies of Design.

The syllabus was reviewed at a meeting of the Department of Information Technologies of Design, Faculty of Aircraft Engineering.

Minutes No. 1 dated 30 August 2024

Head of Department 105 PhD, Associate Professor  Alina ARTOMOVA

(academic degree and title) (signature) (first name and surname)

1 GENERAL INFORMATION

General information about the course is provided in Table 1.1.

Table 1.1 – General information about the course

Item	Description
Code and status	Compulsory course; code as specified in the relevant doctoral programme
Workload	5 ECTS credits, 150 hours
Semester	1
Full-time study	64 contact hours; 86 hours of independent study
Part-time study	16 contact hours; 134 hours of independent study
Learning activities	Lectures, practical classes and independent study
Final assessment	Examination
Language of instruction	Ukrainian

2 COURSE AIM AND PLACE IN THE DOCTORAL PROGRAMME

Course aim — to develop the ability to select and apply information technologies appropriately for collecting, preparing, analysing and interpreting research data, testing scientific hypotheses and ensuring the reproducibility of results.

Course objectives: to master the identification and critical evaluation of data sources; organise research datasets; apply statistical methods and computer modelling; assess uncertainty and the limitations of conclusions; and prepare evidence-based analytical materials for the dissertation and the implementation of research results.

Examples cover the analysis of experimental observations, results of mathematical and computer modelling, algorithm evaluation and the study of complex systems. Students apply the methods to the subject area of their dissertation. Engineering and aerospace cases illustrate general approaches and may be supplemented with comparable examples from other fields.

Prerequisites: knowledge of the fundamentals of research, mathematical methods and statistics acquired during previous studies; basic computer and spreadsheet skills. The specialist knowledge required depends on the subject area of the dissertation research.

Interdisciplinary links: scientific communication, research methodology, research project management and specialist courses within the relevant doctoral programme.

Subsequent application: planning and conducting dissertation research, preparing scientific publications, presenting and defending results, developing research projects, and applying digital methods in research and university teaching.

3 COMPETENCIES

The course develops the following research competencies:

Ability to think abstractly, analyse critically, synthesise information and justify research decisions.

Ability to find, critically evaluate, organise and analyse information from different sources while maintaining academic integrity.

Ability to plan and conduct original research in one’s subject area, obtain substantiated results, and assess their novelty and scope of applicability.

Ability to select and apply data processing methods, mathematical and computer modelling, modern digital technologies, databases and specialist software in research.

Ability to organise a reproducible research process, test hypotheses, document methods and results, present well-reasoned conclusions, and respect rights relating to data and research outputs.

4 LEARNING OUTCOMES AND THEIR ASSESSMENT

Course learning outcome 1. Find and evaluate sources, prepare research data, apply appropriate analytical methods and specialist software, and document procedures so that results can be reproduced.

Course learning outcome 2. Formulate and test hypotheses; substantiate conclusions through theoretical analysis, experimental or empirical data and modelling; and assess errors, uncertainty and limitations.

Course learning outcome 3. Compare digital methods and tools, assess their suitability for one's own research, apply the results in research or university teaching, and present them with supporting arguments.

Learning outcomes and assessment methods are provided in Table 4.1.

Table 4.1 – Learning outcomes and assessment methods

LO	Observable outcome	Assessment
1	The student assembles a research dataset, documents data cleaning, selects an analytical method and reproduces calculations in a software environment.	Practical Assignments 2–4; progress checks
2	Formulates a hypothesis, justifies the testing method, analyses assumptions, and evaluates uncertainty and the limits of conclusions.	Practical Assignments 1–2; defence of results
3	Compares digital research methods and prepares a reproducible example of their application in research practice or teaching.	Practical Assignment 1; demonstration of IT use

5 ORGANISATION OF LEARNING

Learning combines explanations of methods with work on research datasets of different types. Each practical assignment includes a research question, a description of sources, calculations, interpretation and limitations of the result. When using their own data, students obtain permission for its use and anonymise it where necessary.

Teaching methods: problem-based lectures, demonstrations of data processing, research case analysis, practical calculations, discussion of alternative explanations, peer review and consultations. Sources [1–6] are recommended for independent study.

The software environment is selected according to the task and availability: spreadsheets, statistical packages, database tools and visualisation tools. Suitable examples include MATLAB, Mathcad, MAPLE, spreadsheets and the supplied sorting comparison program; Python may be used for machine learning with the lecturer’s agreement. Assessment focuses on the appropriateness of the method and the result, rather than the choice of a particular product.

6 COURSE CONTENT

6.1 Introduction to the course

Basic concepts of systems design, information processing and scientific research. A systems view of the nature and structure of data, variable types and research outputs. Formulating the problem, aim, objectives, object and specific subject of dissertation research. Distinguishing data, results, interpretations and conclusions. Requirements for literature searches, bibliographic references and the presentation of evidence. Overview of the recommended reading and course software.

Workload: full-time study — 3 contact hours and 6 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Prepare the general characteristics of the dissertation research: relevance, aim, objectives, object, specific subject and methods. Identify which claims require verification using data. Results are

documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.2 Life cycle of complex technical systems

Stages in the life cycle of complex technical systems and the characteristics of research, development, testing and certification using information technologies. Data provenance at different stages, completeness, accuracy and comparability. Costs of development, operation, maintenance and retirement. Constructing a life-cycle model of the object under study, formulating assumptions and assessing uncertainty. Selecting sources for analysing the effectiveness of an innovative solution.

Workload: full-time study — 3 contact hours and 5 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Prepare a literature

review on the life cycle of the object under study; compare the authors' approaches and identify unresolved issues for the dissertation summary. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.3 Development and operation of unmanned aircraft systems in airspace

Methods and tools for determining the safety level of unmanned aircraft systems through physical, mathematical and computer modelling. Experimental design, recording parameters, processing observations and verifying the validity of results. Relationships between technical characteristics, costs, reliability and operational risks. Distinguishing measured indicators from modelled indicators. Interpreting data and identifying the limits of transferring conclusions to other operating conditions.

Workload: full-time study — 4 contact hours and 5 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Analyse a modelling example and explain which indicators support the result; record limitations and possible sources of error. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.4 A risk-based approach to managing complex system development projects

Risk-based management of complex system development projects. Comprehensive analysis of the development process, identification of risk factors and assessment of their effects on schedules, costs and results. A functional model of a production system as a basis for identifying the data required. Scenario analysis, sensitivity analysis, expert judgements and justification of management decisions. Formulating testable assumptions and documenting the limitations of the input information.

Workload: full-time study — 6 contact hours and 5 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their

choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Construct a functional representation of the system under study and a list of risks. Explain the choice of analytical method and its connection to the research result. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.5 Fundamentals of designing complex distributed sociotechnical systems

The structure of a complex distributed sociotechnical system, its elements, interrelationships, characteristics and design principles. Examples of production and aerospace systems. Design information systems at development stages and their role in collecting and storing research data. Representing information flows, resources, processes and performance indicators. Aligning the data structure with the research question and checking information for completeness and consistency.

Workload: full-time study — 3 contact hours and 5 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Describe the data structure of your research, information flows and quality-checking rules; prepare questions for consultation. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.6 Design stages for complex distributed sociotechnical systems

Main stages of systems design: defining requirements, constructing models, selecting methods, implementation and verification of results. Applying standards and documentation requirements when designing a technical system. Constructing a minimised generalised algorithm as an example of formalisation. Checking calculations and ensuring the reproducibility of the analytical procedure. Automating mathematical calculations in Mathcad and MAPLE and checking units of measurement and admissible parameter values.

Workload: full-time study — 3 contact hours and 5 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of

conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Review the instructions for the four Mathcad/MAPLE tasks and your assigned variant, check the input data and plan the calculation sequence. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.7 A systems representation of an automated ground-based spacecraft control complex

The operation of Ukraine's automated ground-based spacecraft control complex as an example of a complex sociotechnical system. Systems representation using a "systems cube". Description layers: goal, functional and information models, an organisational structure model, a management model, and hardware and software resources. Superposition of models to synthesise a generalised process network. Interactions between operations, data transmission, quality management and risk management. Interpretation of performance indicators, resource expenditure and model limitations.

Workload: full-time study — 4 contact hours and 5 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Prepare a systems model of the research object, describe the interactions between its components and briefly justify the assumptions used. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.8 Data processing and analysis methods for characterising complex systems

Analytical and statistical modelling, simulation, and processing expert judgements to calculate reliability and monitor the operation of complex systems, including the automated ground-based spacecraft control complex. Knowledge-based models and selection of information technologies appropriate to the dissertation research. Data cleaning, descriptive statistics, hypothesis testing, correlation and

regression analysis. Machine learning in MATLAB, processing large datasets, evaluating model quality and preventing overfitting. Calculating production system equipment requirements as an example of applying the results.

Workload: full-time study — 4 contact hours and 6 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Complete the laboratory tasks in ML.docx using MATLAB, prepare the report and answers to review questions, and substantiate the analytical results. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.9 Fundamentals of real-time systems control

Characteristics of systems whose performance depends on the timing of information acquisition and processing. The basic procedure for developing real-time control systems. Performance constraints, latency, data freshness and computational reliability. Measuring algorithm execution time, repeated runs, and distinguishing random fluctuations from systematic patterns. Assessing how computational costs affect the suitability of a digital solution for monitoring the processes under study.

Workload: full-time study — 4 contact hours and 2 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Plan the sorting experiment: array sizes, execution conditions, repetitions, the method for summarising results and the recording of the environment. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions

reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.10 Parameter types and the structure of sensing and information conversion devices

The structure of data acquisition systems, sensors and information conversion; the sequence for selecting measurement and analysis tools. Designing data acquisition systems and generating control actions in automated real-time systems. Measurement errors, sampling frequency, missing values, outliers and timestamp alignment. A model of an enterprise’s production structure and its information support. Preparing a dataset for machine learning, describing variables and checking source quality.

Workload: full-time study — 4 contact hours and 10 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Prepare and check

the data for the machine learning tasks; describe missing values, transformations and data splitting without information leakage. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.11 Development and formalisation of control algorithms

The language of regular algorithm schemes (RAS) as a means of describing the operation of a complex system. Basic constructs, sequences of actions, branching and repetition; examples of algorithm formalisation. Checking correctness and comparing the computational efficiency of implementations. Empirical evaluation of sorting algorithms and the relationship between execution time and the number of elements. Distinguishing theoretical complexity from measured time; characteristics of the average and worst cases.

Workload: full-time study — 3 contact hours and 4 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where

the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Carry out repeated measurements of sorting time, retain the raw results, plot charts and explain the differences observed. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.12 Development of process control programs for real-time systems

The sequence of developing and implementing control programs for real-time systems, with examples of operation and verification. Formalising input data, constraints and results. Designing a transport and storage system as an example of analysing material flows, throughput and costs. Automating repetitive calculations in mathematical software packages; comparing results across tools, checking boundary cases and documenting algorithms.

Workload: full-time study — 3 contact hours and 4 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their

choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Perform calculations in Mathcad and MAPLE, verify the results using an alternative approach, and prepare reproducible files and a report. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.13 Models for representing production

Production processes, the structure of factory management and the main functions of its departments. A technological process as an object of automation and control. A network schedule for designing a complex system, dependencies between activities, durations and resource constraints. Models of costs, productivity and equipment utilisation. Using computational and statistical results to support decisions; presenting models and conclusions in the written summary of the dissertation research.

Workload: full-time study — 3 contact hours and 4 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Relate the production process model to the dissertation research question; synthesise the literature, approaches to solving the tasks and criteria for achieving the aim. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.14 Formal representation of technological processes using regular algorithm schemes

Formalising technological processes and representing the assembly of a complex product in space and time. A generalised technological algorithm as an initial model of the production process. Examples of process descriptions using RAS; methods for allocating resources across project activities. Designing an automated control system with specified parameters as a learning case. Checking model assumptions, ensuring parameter consistency, and using Mathcad and MAPLE for reproducible calculations.

Workload: full-time study — 4 contact hours and 4 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of

conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Complete the four Mathcad/MAPLE tasks, explain the algorithms and resulting values, and document limitations and conclusions. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.15 Constructing a minimised generalised technological process for a set of linear algorithms

Structural synthesis of systems that implement a set of processes using a minimum set of resources. Constructing and analysing a minimised generalised technological process (MGTP) using RAS for linear algorithms. Examples of technological process synthesis and optimisation of project work plans. Criteria for comparing alternatives: time, resources, costs and constraints. Quantitative evidence of the advantages of the proposed solution and preparation of the evidence supporting dissertation conclusions.

Workload: full-time study — 5 contact hours and 7 hours of independent study; part-time study — 1 contact hour and 8 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Compare possible approaches to addressing the dissertation objectives; prepare tables, charts and a justification of the chosen approach for the extended dissertation abstract. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.16 Constructing a minimised generalised technological process for nonlinear algorithms

The general case of constructing an MGTP for processes with nonlinear structures, branching and repetition. Characteristics of structural synthesis using RAS and the construction and analysis of a generalised technological process. Project scheduling with fuzzy representations of activity durations. Sensitivity and scenario

analysis; distinguishing uncertainty in input data from errors attributable to the method. Critical discussion of the limits of applicability of the results obtained.

Workload: full-time study — 4 contact hours and 4 hours of independent study; part-time study — 1 contact hour and 7 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student's own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Test the robustness of conclusions to changes in assumptions; distinguish results already obtained from planned research, and prepare answers to questions. Results are documented with references to sources, a description of the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

6.17 Constructing a technological production structure based on a generalised technological process

Production system throughput and calculation of the number of workstations in a technological structure for a specified productivity level. Identifying bottlenecks and assessing utilisation and resource efficiency. Bringing together modelling results, automated calculations and data analysis. Preparing the general characteristics of the dissertation research and checking whether conclusions address its aim and objectives. Presentation, oral reporting and defence of the results obtained.

Workload: full-time study — 4 contact hours and 5 hours of independent study; part-time study — 0 contact hours and 7 hours of independent study.

Lecture-based study. An in-person lecture, recorded video lecture or online lecture, depending on the organisation of teaching. Explanations of concepts and the sequence of applying methods, exposition, dialogue and class discussion are combined with presentations, illustrations, demonstrations of calculations and independent observation. Discussion covers initial assumptions, data sources, the validity of conclusions and the connection between the material and the student’s own research. Where no contact hours are allocated, the material is studied independently using resources supplied by the lecturer.

Practical study. Oral questioning, topic-based testing, worked examples and consultations on the four integrated practical assignments. Students explain their choice of tools, demonstrate interim results and discuss errors identified. Preparation materials and completed tasks are uploaded to the learning management system, where the lecturer provides feedback. Topic-based exercises form part of the relevant integrated assignment and do not earn additional points.

Independent study. Study of teaching materials and literature, and preparation of questions for in-person or online consultation with the lecturer. Complete the extended dissertation abstract, align the presentation with it, prepare the oral report, and check that every conclusion is supported by results or clearly identified as an expected outcome. Results are documented with references to sources, a description of

the tools used and an explanation of the conclusions reached. Where needed, sections of the presentation and oral report are prepared to reflect the content of the written submission.

7 ALLOCATION OF HOURS BY TOPIC

Contact hours cover lectures and practical classes. Their allocation between lectures and practical classes is specified in the working curriculum. Independent study includes the completion of four integrated assignments and the defence of the dissertation summary.

The allocation of study hours is provided in Table 7.1.

Table 7.1 – Allocation of study hours

Topic	**Full-time contact**	**Full-time self-study**	**Part-time contact**	**Part-time self-study**
1	3	6	1	8
2	3	5	1	8
3	4	5	1	8
4	6	5	1	8
5	3	5	1	8
6	3	5	1	8
7	4	5	1	8
8	4	6	1	8
9	4	2	1	8
10	4	10	1	8
11	3	4	1	8
12	3	4	1	8
13	3	4	1	8
14	4	4	1	8
15	5	7	1	8
16	4	4	1	7
17	4	5	0	7
Total	**64**	**86**	**16**	**134**

Full-time study: 64 + 86 = 150 hours.

Part-time study: 16 + 134 = 150 hours.

8 INDEPENDENT STUDY AND INDIVIDUAL ASSIGNMENTS

The main individual assignment is a written summary of the dissertation research (an extended dissertation abstract prepared for the course), a presentation and an oral report. It constitutes Practical Assignment 1 and is completed throughout the semester. The other three assignments develop proficiency in data processing tools, calculation automation and algorithm evaluation. No additional course project is required.

The scientific content of the extended dissertation abstract is determined by the dissertation topic and the actual stage of the research. Expected results must be clearly distinguished from results already obtained; plans must not be presented as completed research achievements.

9 PRACTICAL ASSIGNMENTS

9.1 Extended dissertation abstract, presentation and oral report

The extended dissertation abstract, presentation and oral report on the dissertation topic constitute the main practical assignment of the course. The abstract provides a structured overview of the student's own research: its general characteristics, literature review, methods, results and conclusions.

Aim — to develop a coherent account of the dissertation research, critically analyse the literature, demonstrate approaches to addressing the research objectives, and substantiate achievement of the research aim on the basis of the available results.

Assignment content. Present the relevance, problem, aim, objectives, object, specific subject and methods of the research. Review and analyse the literature: compare approaches, identify the limitations of existing solutions and unresolved issues. Describe the input data, selected information technologies, mathematical or computer models, hypothesis-testing approach and results. Substantiate the connection between the objectives, results and conclusions, and formulate the scientific novelty and practical significance within the scope of the research actually completed.

If the research is at an early stage, present a reasoned plan for testing hypotheses, the expected contribution, criteria for achieving the aim and the preliminary results available. The reference list must correspond to the citations in the text. Tables and charts must have titles, labels, units of measurement and explanations.

The presentation reflects the content of the extended dissertation abstract: the general research characteristics, literature review findings, selected methods, key results, conclusions and limitations. The oral report explains the research logic; the student answers questions about their own decisions, data and calculations. Submit the extended dissertation abstract, presentation and calculation materials or illustrations needed to verify the conclusions. The lecturer specifies the deadlines, presentation duration and length requirements.

Assessment of the extended dissertation abstract, presentation and oral report is set out in Table 9.1.

Table 9.1 – Assessment of the extended dissertation abstract, presentation and oral report

Criterion	Maximum
General research characteristics and alignment of aim and objectives	8
Critical review and analysis of the literature	10
Methods, approaches to addressing objectives and use of IT	12
Evidence supporting results, conclusions and limitations	10
Presentation and its consistency with the extended dissertation abstract	5
Oral report and answers to questions	5
Total	50

9.2 Machine learning and processing large datasets

Using MATLAB, complete the laboratory tasks specified in ML.docx. Prepare a report containing the task statements, a description of the data, the sequence of steps, code fragments or model files, results, conclusions and answers to review questions. Laboratory task numbers and instructions are provided in ML.docx.

In the report, explain the data transformations applied, the choice of method and the quality metrics. If the task involves model training, describe the data split, evaluation using data not used for training, and measures to prevent overfitting. Demonstrate that the result is reproducible and explain possible limitations.

The assignment score q is determined on a scale of 0–100. The contribution to the course grade is $0.20 \times q$, up to a maximum of 20 points. Completing the specified set of laboratory tasks is necessary to reach the corresponding level, but does not guarantee it without adequate quality, reporting and defence.

Machine learning assignment achievement levels are provided in Table 9.2.

Table 9.2 – Machine learning assignment achievement levels

Assignment score q	Required MATLAB tasks	Course points
0–59	Incomplete basic set or substantial errors	0–11.8
60–74	Laboratory tasks 1 and 2; adequate report and answers	12–14.8
75–89	Laboratory tasks 1, 2, 3 and 4; substantiated results	15–17.8
90–100	Laboratory tasks 1–6; full analysis, verification and defence	18–20

To calculate q transparently, laboratory tasks 1–2 are worth up to 74 points in total; tasks 3–4 add up to 15 points; and tasks 5–6 add up to 11 points. Each group is assessed for correctness, completeness of the report, answers to review questions and explanation of results. Before progressing to the next level, the preceding set must be completed and defended; shortcomings may result in a score below the stated range.

Python alternative. Students who wish to use Python must agree this with the lecturer in advance. The materials “Lab 1”, “Lab 2” and “Labs 3–7” are used. Before work begins, the lecturer establishes how these tasks correspond to the three MATLAB achievement levels and informs the student. The maximum contribution remains 20 points; the choice of language does not earn additional points.

Guidance for completing the laboratory tasks:

https://drive.google.com/file/d/1bUAadS525HFM56cLkgblbzCON_K7AhE5/view?usp=sharing

9.3 Automating calculations in Mathcad and MAPLE

Complete four tasks using Mathcad and MAPLE according to the instructions provided by the lecturer. The teaching materials specify how tasks are distributed between the packages; both systems must be represented in the submission. For each task, provide the task statement, input data, mathematical formulation, calculation sequence, result, verification and conclusion.

Select the task variant according to the first letter of your surname, as shown in the table. The same variant number applies to all four tasks unless the task instructions specify otherwise.

Task variant selection for Mathcad and MAPLE is shown in Table 9.3.

Table 9.3 – Task variant selection for Mathcad and MAPLE

First letter of surname (Ukrainian spelling)	Variant
А, К, Ф	1
Б, Л, Х	2
В, М, Ц	3
Г, Н, Ч	4
Д, О, Ш	5
Е, П, Щ	6
Є, Р, Ю	7
Ж, С, Я	8
З, Т	9
І, У	10

For surnames beginning with the Ukrainian letters Ґ, И, Ї or a letter not listed in the table, the lecturer assigns a variant before work begins.

Submit a report and Mathcad/MAPLE working files sufficient to reproduce the calculations. Check the domain of admissible values, units of measurement, accuracy, and agreement between numerical and symbolic results where applicable. During the defence, explain the functions used, the sequence of steps and the results obtained.

Assessment of calculations in Mathcad and MAPLE is set out in Table 9.4.

Table 9.4 – Assessment of calculations in Mathcad and MAPLE

Criterion	Maximum
Four tasks: correct formulation, implementation and result — up to 3 points each	12
Verification, report presentation, reproducible files and explanations during the defence	3
Total	15

9.4 Evaluating algorithm efficiency

Evaluate the efficiency of different sorting algorithms by running the supplied program several times with different numbers of elements. Select a range of array sizes that reveals changes in performance, and carry out at least three repetitions for each combination of size and algorithm. Record the hardware and software environment, input data type and units used to measure time.

Compare the algorithms under identical conditions and, if the program permits, using identical copies of the input array. Retain the raw measurements, calculate the mean or median time, and explain the choice of measure. If the program does not allow control over the input data or measurement precision, state this as a limitation of the experiment.

Plot two charts showing execution time against the number of elements: one for algorithms with quadratic growth, $O(n^2)$, and one for algorithms with characteristic growth of O(n log n). Label the axes with the number of elements and time, and add a legend. This separation makes differences visible that would be obscured on a shared scale.

For quicksort, O(n log n) describes average-case complexity, whereas worst-case complexity is $O(n^2)$. The complexity of Shell sort depends on the gap sequence, so it should be presented separately or its grouping should be explained. An experimental chart illustrates the behaviour of an implementation but does not prove its asymptotic complexity.

Add conclusions: which algorithms are faster at different input sizes, how execution time changes, whether the observations agree with theory, and what limits the validity of the comparison. Upload the measurement table, charts and conclusions to the learning management system. The supplied example illustrates presentation format and must not be used as a source of data to copy.

Example submission: https://docs.google.com/spreadsheets/d/1n-sGbT6zOk_0VemAvDICgMMuWlT6bbtT/

Sorting comparison program: https://drive.google.com/file/d/1MiNCQjUDfQL18UMuSOKH5P0NWeYMcp8O/

Assessment of algorithm efficiency evaluation is set out in Table 9.5.

Table 9.5 – Assessment of algorithm efficiency evaluation

Criterion	Maximum
Experimental plan and comparability of conditions	3
Repeated measurements and a results table	4
Two correctly presented charts	4
Substantiated conclusions, limitations and defence	4
Total	15

10 ASSESSMENT AND GRADING CRITERIA

The allocation of points across practical assignments is provided in Table 10.1.

Table 10.1 – Allocation of points across practical assignments

Practical assignment	**Maximum points**
1. Extended dissertation abstract, presentation and oral report	50
2. Machine learning and processing large datasets	20
3. Automating calculations in Mathcad and MAPLE	15
4. Evaluating algorithm efficiency	15
Total	100

The semester grade is calculated using the following formula:

$$S = B_1 + 0.20q + B_3 + B_4,$$

where B_1 is the score for Assignment 1 (0–50), q is the score for Assignment 2 on its internal scale (0–100), and B_3 and B_4 are the scores for Assignments 3 and 4 (0–15 each). The total is rounded to the nearest whole point once, after summation, with halves rounded up. The extended dissertation abstract, presentation and oral report carry the greatest weight: 50% of the total.

Continuous assessment covers the review of submitted materials and the defence of four practical assignments. During consultations, students present their literature review, the general characteristics of their dissertation and interim data processing results. Completed calculations, sorting experiment results, the extended dissertation abstract and the presentation are assessed during the defence of the relevant assignments using the criteria in Section 9.

Final assessment is an examination, as specified in the doctoral programme. With the student’s agreement, a semester score of 60–100 may be accepted as the final grade. To qualify, the student must complete and defend all four assignments, earn at least 60% of the maximum score for each, and complete the basic set of machine learning tasks.

Where an examination is taken, it covers the defence and verification of results from all four assignments using the same scale: 50 + 20 + 15 + 15 = 100. This includes

clarification of the methods and conclusions in the extended dissertation abstract, and explanation or reproduction of the machine learning results, mathematical calculations and algorithm experiment. Examination points are not added to semester points; the final grade is determined by the examination result. Admission to the examination, resits and appeals are governed by university regulations.

The grading scale is provided in Table 10.2.

Table 10.2 – Grading scale

Points	Grade	Description
90–100	Excellent	Methods are applied appropriately; results are reproducible and conclusions are critical and evidence-based.
75–89	Good	The main results are correct; there are some inaccuracies or incomplete explanations.
60–74	Satisfactory	The basic tasks are completed, but analysis and independent reasoning are limited.
0–59	Unsatisfactory	Results are insufficient or substantial errors distort the conclusions.

Additional activities may be recognised only through an agreed procedure as evidence of the relevant learning outcomes within the established maximum scores. The total cannot exceed 100 points; the same results cannot earn points twice.

11 COURSE POLICIES

Attendance and deadlines. Students participate in practical classes and submit assignments by the agreed deadlines. Missed classes are made up by completing and defending the relevant assignments. Where there are valid reasons, including communication disruptions or security restrictions, the format and deadlines are agreed with the lecturer.

Academic integrity. Sources of data, methods, text and code fragments must be acknowledged. Fabrication, falsification, plagiarism and concealment of changes to data are prohibited. The percentage of textual similarity does not by itself determine whether a submission meets academic integrity requirements; the nature of the borrowed material and the adequacy of citations are assessed.

Use of AI tools. Any supporting use must be described in the submission, identifying the tool and the type of assistance. Students verify calculations, facts and references and explain the result themselves. Confidential or personal data must not be disclosed to third-party services without an appropriate basis. Conditions for using supporting tools during assessment are specified in the task.

Communication and appeals. Consultations, feedback and discussions of grades take place through the agreed course channels. Disputes, conflicts and breaches of academic integrity are considered under university procedures, with the opportunity to provide explanations and appeal a decision.

12 TEACHING AND LEARNING RESOURCES

Course resources include the syllabus, lecture materials, datasets, instructions for the four practical assignments, ML.docx and the Mathcad/MAPLE task variants, assessment criteria, examples of how to present results, and self-assessment questions. The lecturer provides the current link and access instructions through the KhAI Mentor learning management system (https://mentor.khai.edu/).

13 RECOMMENDED READING

Core reading

1. Stepashko V. S., Bulhakova O. S., Zosimov V. V. Iterative Algorithms of Inductive Modelling. Kyiv: Naukova Dumka, 2018. [In Ukrainian].

2. Vazhynskyi S. E., Shcherbak T. I. Research Methods and Organisation. Sumy: A. S. Makarenko Sumy State Pedagogical University, 2016. 260 pp. [In Ukrainian].

3. Strelkova H. H., Fedosenko M. M., Zamulko A. I., Ishchenko O. S. Fundamentals of Scientific Research. Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2019. 120 pp. [In Ukrainian].

4. Pasichnyk V. V., Vykliuk Ya. I., Kaminskyi R. M. Modelling Complex Systems. Lviv: Novyi Svit — 2000, 2017. 404 pp. [In Ukrainian].

5. Prokopenko T. O. Systems Theory and Systems Analysis. Cherkasy: Cherkasy State Technological University, 2019. 139 pp. [In Ukrainian].

Further reading

6. Mailath G. J. Modeling Strategic Behavior: A Graduate Introduction to Game Theory and Mechanism Design. World Scientific, 2018.

Information resources

V. I. Vernadskyi National Library of Ukraine; V. H. Korolenko Kharkiv State Scientific Library; official documentation for the selected statistical package; and methodological notes accompanying the statistical datasets used. Specific sources and software versions are identified in the assignments and reports.