Syllabus of the educational component

Program of educational discipline

Control Theory

Code and name of specialty
113 Applied mathematics

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Intelligent data analysis

Department
Computer mathematics and data analysis

Level of education
Bachelor's level

Type of discipline
Special (professional), Mandatory

Semester
6

Language of teaching
Ukrainian

Teachers and developers

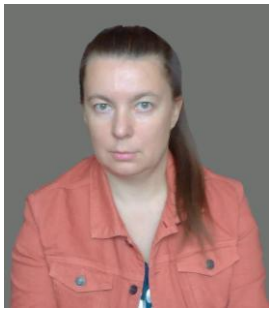
Lyubchyk Leonid Mykhailovych

Leonid.Liubchyk@khpi.edu.ua

Doctor of technical sciences, professor, professor of the Department of Computer Mathematics and Data Analysis of NTU "KhPI".

Work experience since 1981. The number of scientific and educational publications is more than 200. Leading lecturer in the disciplines: "Control theory", "Incorrect problems of data processing", "Predictive analysis". Scientific directions: control and decision-making under conditions of uncertainty, machine learning.

Learn more about the teacher on the department's website
http://web.kpi.kharkov.ua/kmmm/uk/o_kafedre_ua/profesorsko-vikladatskij-sklad/lyubchik-leonid-mihajlovich/



Kostyuk Olga Vasylivna

Olha.Kostiuk@khpi.edu.ua

Candidate of Technical Sciences, Associate Professor, Associate Professor of the Department of Computer Mathematics and Data Analysis of KhPI National Technical University.

Work experience since 2000. The number of scientific and educational publications is more than 40. Leading lecturer in the disciplines: "Theory of decision-making", "Fuzzy models and methods". Scientific directions: management and decision-making under conditions of uncertainty, fuzzy mathematics, and forecasting methods.

Детальніше про викладача на сайті кафедри
http://web.kpi.kharkov.ua/kmmm/uk/o_kafedre_ua/profesorsko-vikladatskij-sklad/kostyuk-olga-vasilivna

General information

Annotation

The discipline is aimed at studying the principles of control of dynamic systems. Methods of building mathematical models of objects and control systems, principles of control and structure of control systems, methods of building mathematical models in "input-output" variables and in state variables, application of the apparatus of transfer functions and models in the space of states are studied. Methods of analysis of control systems, time and frequency characteristics, methods of analysis of stability, and quality of control systems are considered. The methods of synthesis of control systems with given properties are studied, particularly the stabilization and optimization of transient processes. With the help of state space methods, the solutions of problems of synthesis of feedback by state and output, problems of synthesis of state observers, and synthesis of systems with observers in the feedback circuit are considered.

Purpose and objectives of the disciplines

The purpose of studying the discipline is to study the theory and principles of control, acquire theoretical knowledge and practical skills in modeling, analysis, and synthesis of control systems, in particular, analysis of their stability and quality, construction and optimization of control algorithms, skills in solving practical control problems.

Format of classes

Lectures, laboratory work, self-learning, consultations. The final control is an exam.

Competences

GC 5. Ability to conduct research at the appropriate level.
GC 8. Knowledge and understanding of the subject area and understanding of professional activity.
GC 10. Skills in the use of information and communication technologies.
SC 3. The ability to choose and apply mathematical methods for solving applied problems, modeling, analysis, design, management, forecasting, and decision-making.
SC 4. Ability to choose and apply numerical methods for solving optimization problems
SC10. Ability to conduct mathematical and computer modeling, data analysis and processing, computational experiments, and solving formalized problems using specialized software tools.
SC15. The ability to formulate a mathematical statement of a problem, based on a statement in the language of the subject field, and to choose a method of its solution ensures the required accuracy and reliability of the result.

Learning outcomes

LO 3. Formalize tasks formulated in the language of a specific subject area; formulate their mathematical statement and choose a rational solution method; solve the obtained problems by analytical and numerical methods, to evaluate the accuracy and reliability of the obtained results.
LO 6. To have the basic methods of developing discrete and continuous mathematical models of objects and processes, analytical research of these models for the existence and unity of their solution.
LO 10. To have techniques for choosing rational methods and algorithms for solving mathematical problems of optimization, operations research, optimal management and decision-making, and data analysis.
LO 13. To use specialized software products and software systems of computer mathematics in practical work.

Scope of the discipline

The total volume of the discipline is 90 hours. (3 ECTS credits): lectures – 16 hours, laboratory work – 28 hours, independent work – 46 hours.

Prerequisites for studying the discipline

Mathematical analysis", "Linear algebra", "Differential equations and complex analysis", "Mathematical and computer modeling".

Features of the discipline, methods, and technologies of education

Lectures are held interactively with presentations and the use of multimedia technologies. Laboratory works are carried out using free software - Scilab, and Xcos libraries. Educational materials are available to students in the Microsoft 365 environment through OneDrive and OneNote Class Notebook.

Program of educational discipline

Topics of lectures

Topic 1. Introduction. Basic concepts of control theory. Mathematical models of control systems.
Basic concepts and terminology of control theory. Typical tasks and management principles. The structure of control systems. Mathematical models of objects and control systems. Input-output models and state-space models. Transformation of models.
Topic 2. Transmission functions and frequency characteristics.
Laplace transform. Structure and properties of transfer functions. Poles and zeros. Algebra of transfer functions. Frequency characteristics of dynamic systems.
Topic 3. Systems with feedback. Persistence.
Stability of control systems. Algebraic and frequency criteria of stability.
Topic 4. Systems with feedback. Quality.
Quality of control systems. Quality indicators of transitional and established processes. Control precision.
Topic 5. Synthesis of feedback systems.
Polynomial and parametric synthesis. Root hodograph method. PID - regulators.
Topic 6. State space method.
Implementation of systems in the space of states. Dynamics of controlled systems in the space of states, transition, and fundamental matrices. Matrix exponent and its application.
Topic 7. Feedback by state vector.
The problem of modal control. Controllability of dynamic systems. Kalman criteria. Synthesis of feedback.
Topic 8. Dynamic observers.
Assessment of condition. Feedback based on state vector estimates. Control systems with observers, the principle of algebraic separation.

Topics of practical classes

Practical classes within the discipline are not provided.

Topics of laboratory work

Topic 1. Formation of models of dynamic systems.
Topic 2. Transformation of models of dynamic systems.
Topic 3. Study of time characteristics of dynamic systems.
Topic 4. Study of the response of dynamic systems to typical influences.
Topic 5. Study of frequency characteristics of dynamic systems.
Topic 6. Study of passage of harmonic signals through linear dynamic systems.
Topic 7. Control work No. 1. Colloquium.
Topic 8. Analysis of stability of systems. Algebraic and frequency criteria of stability.
Topic 9. Study of the stability of dynamic systems.
Topic 10. Study of deviation control systems.
Topic 11. Study of systems with a disturbance compensator.
Topic 12. Study of a tracking system with a forcing regulator.
Topic 13. Synthesis of the modal control system.
Topic 14. Study of a system with modal control.
Topic 15. Study of a system with a spur guard in the control loop.
Topic 16. Control work No. 2. Colloquium.

Self-learning

Topic 1. Study of methods of building mathematical models of dynamic systems
Topic 2. Familiarization with Scilab, X cos simulation systems.
Topic 3. Typical links of dynamic systems and their characteristics
Topic 4. Study of time and frequency characteristics of dynamic systems.
Topic 5. Study of algebraic and frequency stability criteria
Topic 6. Study of quality indicators of transient processes.
Topic 7. Study of methods of stabilization of control systems.
Topic 8. Study of methods of synthesis of feedback on state variables and solution of the problem of modal control.

Non-formal education

Within the framework of non-formal education according to the relevant Regulation (http://surl.li/pxssv), the educational component or its separate topics can be taken into account in case of independent completion of professional courses/training, obtaining civic education, online education, professional internship, etc. In particular, individual topics of this component may be taken into account upon successful completion of the following courses:
Topics 1,2.
Coursera: Control Systems Analysis: Modeling of Dynamic Systems
https://www.coursera.org/learn/modeling-feedback-systems?language=English
Feedback Control Design ENGR105
Stanford School of Engineering
https://online.stanford.edu/courses/engr105-feedback-control-design
Topics 3,4.
Introduction To Control Design Techniques ENGR205
Stanford School of Engineering
https://online.stanford.edu/courses/engr205-introduction-control-design-techniques
Topics 5 - 8.
Feedback Control Design ENGR105
Stanford School of Engineering
https://online.stanford.edu/courses/engr105-feedback-control-design
Advanced Feedback Control Design AA212
Stanford School of Engineering
https://online.stanford.edu/courses/aa212-advanced-feedback-control-design

Literature and educational materials

Basic literature

1. Крак Ю.В. Основи теорії керування та робототехніки: Навчальний посібник для студентів спеціальності "Інформатика". – К.: "Київський університет", 2021.
https://csc.knu.ua/media/filer_public/9b/3b/9b3bdba9-15dc-4c50-ad54-2bb54713b580/osnovi_teoriyi_keruvannia_ta_robototekhniki.pdf
2. Методи сучасної теорії управління: підручник / Ладанюк А. П., Луцька Н. М., Кишенько В. Д., Власенко Л.О., Іващук В. В. – Київ : Видавництво Ліра – К, 2018.
http://pdf.lib.vntu.edu.ua/books/2019/Ladanuk_2019_368.pdf
3. О. Й. Штіфзон, П. В. Новіков, В.П. Бунь. Теорія автоматичного управління: Навчальний посібник. Київ : КПІ ім. Ігоря Сікорського, 2020.
https://ela.kpi.ua/bitstream/123456789/41587/1/%D0%A2eoriia_avtomat_uprav.pdf
4. Zdzislaw Bubnicki. Modern Control Theory. Polish Scientific Publishers PWN, 2022.
https://theswissbay.ch/pdf/Gentoomen%20Library/Misc/Modern%20Control%20Theory.pdf

Additional literature

5. S. A. Frank. Control Theory. Tutorial Basic Concepts Illustrated by Software Examples. Springer, 2019.
https://library.oapen.org/bitstream/id/ca08ee4d-3639-43d0-81b7-f53ebdfd1e03/1002170.pdf

6. Tore Hägglund. Automatic control. Lecture Notes. Lund University, Faculty of Engineering 2021.
https://www.control.lth.se/fileadmin/control/Education/EngineeringProgram/FRTF05/engforel.pdf
7. А. О. Данькевич, В. С. Цапар. Теорія автоматичного керування. Сучасна теорія керування: Лабораторний практикум. Київ: КПІ ім. Ігоря Сікорського, 2022. – 30 с.
https://ela.kpi.ua/bitstream/123456789/52386/1/TAK_Lab.pdf
8. Халіков В. А. Теорія автоматичного керування. Практикум. Електронне мережне навчальне видання. – Київ, КПІ ім. Ігоря Сікорського, 2022.
https://ela.kpi.ua/bitstream/123456789/48893/1/TAK_Praktykum.pdf

Electronic resources

1. Satish Annigeri. An Introduction to Scilab. 2019.
http://www.bad.org.tr/mate/Belgeler/Scilab_Manu_in.pdf
https://www.scilab.org/
2. Introduction to Xcos. A Scilab Tool for Modeling Dynamical Systems.
https://www.researchgate.net/publication/343472236_Introduction_to_Xcos_A_Scilab_Tool_for_Modeling_Dynamical_Systems
https://www.scilab.org/software/xcos

Evaluation system

Criteria for evaluating student performance and distribution of points

The student's points in the discipline are calculated according to the following ratio:

- test papers: 20% of the semester grade;
- self-learning: 15% of the semester grade;
- colloquium: 25% of the semester grade;
- exam: 40% of the semester grade.

Rating scale

Total points	National assessment	ECTS
90–100	Perfectly	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactorily	D
60–63	Satisfactorily	E
35–59	Unsatisfactorily (further study required)	FX
1–34	Unsatisfactorily (further study required)	F

Norms of academic ethics and policy of the course

The student must adhere to the "Code of Ethics of Academic Relations and Integrity of NTU "KhPI": show discipline, education, benevolence, honesty, and responsibility. Conflict situations should be openly discussed in study groups with the teacher, and if it is impossible to resolve the conflict, it should be brought to the attention of the employees of the institute's directorate.

Regulatory and legal support for the implementation of the principles of academic integrity of NTU "KhPI" is posted on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Syllabus approved by	Date of approval, signature 29.08.2024		Head of the department Olena AKHIIEZER
	Date of approval, signature 29.08.2024		Guarantor of Educational Program Olena AKHIIEZER