Silabus
selective educational component
Control systems with artificial intelligence

Name of the discipline:	**Control systems with artificial intelligence**
Level of higher education:	**Second (master's) degree**
Course page in Moodle:	**https://dl.khadi.kharkov.ua/course/view.php?id=3047**
Scope of the educational component	**4 credits (120 hours)**
Form of final control	**Credit**
Consultations:	**on schedule**
Name of the department:	**Department of AKIT**
Language of instruction:	**Ukrainian**
Course leader:	**Sergiy Zaporozhetsev, PhD, Associate Professor**
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Summary of the educational component:
The purpose of the educational component is to develop students' theoretical and practical knowledge and skills in the field of artificial intelligence technology used in control systems for complex organizational and technical objects of instrumentation, road and transport industries.

Subject*:* a pedagogically adapted system of concepts about artificial intelligence technologies, methods of developing systems with their participation and features of application.

The main objectives of the discipline are:
- substantiation and presentation of the theoretical and methodological foundations for building control systems with artificial intelligence;
- studying the principles and technology of building artificial intelligence systems and their application in control systems;
- developing skills in selecting machine learning models for different classes of tasks;
- developing skills in implementing artificial intelligence systems in specialized software environments;
- developing skills in analyzing the results of creating artificial intelligence systems.

Prerequisites for studying the educational component:
Higher mathematics.
Physics.
Probability theory.
Algorithmization and programming or computer science.

Competencies acquired by the applicant:
General competencies:
Ability to conduct research at the appropriate level.
Ability to generate new ideas (creativity).
Ability to think abstractly, analyze and synthesize.

Ability to communicate in Ukrainian and foreign languages in writing and orally.

Special (professional) competencies:

Ability to automate complex technological objects and complexes, create cyber-physical systems based on intelligent control methods and digital technologies using databases, knowledge bases, artificial intelligence methods, robotic and intelligent mechatronic devices.

Ability to analyze production and technological systems and complexes as objects of automation, determine methods and strategies for their automation and digital transformation.

Ability to integrate knowledge from other fields, apply a systematic approach and take into account non-technical aspects when solving engineering problems and conducting research.

Ability to apply specialized software and digital technologies to solve complex problems and issues of automation and computer-integrated technologies.

Ability to present the results of research activities, prepare scientific publications, participate in scientific discussions at scientific conferences, symposia, and carry out pedagogical activities in educational institutions.

Learning outcomes in accordance with the educational program:

To create automation systems, cyber-physical production based on the use of intelligent control methods, databases and knowledge bases, digital and network technologies, robotic and intelligent mechatronic devices.

To apply specialized conceptual knowledge, including modern scientific achievements, as well as critical understanding of modern problems in the field of automation and computer-integrated technologies to solve complex problems of professional activity.

Apply modern approaches and methods of modeling and optimization to research and create effective automation systems for complex technological and organizational and technical objects.

To develop computer-integrated control systems for complex technological and organizational and technical objects, applying a systematic approach, taking into account non-technical components of automation objects assessment.

Communicate fluently in the state and foreign languages orally and in writing to discuss professional problems and results of activities in the field of automation and computer-integrated technologies, present research results and innovative projects.

To apply modern mathematical methods, methods of automatic control theory, reliability theory and system analysis to research and create automation systems for complex technological and organizational and technical objects, cyber-physical production.

To develop and use specialized software and digital technologies to create automation systems for complex organizational and technical facilities, to be proficient in special software tools.

Collect the necessary information using scientific and technical literature, databases and other sources, analyze and evaluate it.

Thematic plan

No. of the topic	Name of the topic (LC, LC, PR, NW, NW)	Number of hours	
		face-to-face	correspondence
1	2	3	4
1	LC. Introduction to control systems with artificial intelligence. Basic concepts and approaches. Examples of IDEs (Anaconda, Jupyter Notebook/JupyterLab, Google Colab). Python basics.	2	
	PR. Solving simple problems using Python methods.	2	
	SR. Kaggle platform and its resources.	10	
2	LC. Libraries for working with Python artificial intelligence models (pandas, numpy, sklearn). Exploratory data analysis (EDA), its goals and types, implementation of EDA in Python.	2	
	PR. Working with basic Python libraries for data mining.	2	
	CP. Functional programming in Python.	10	
3	LC. Types of machine learning tasks (with a teacher, without a teacher, with reinforcement). Model metrics. Basic libraries for visualization.	2	
	PR. Data visualization.	2	
	SR. The concept of cross-validation and search for model hyperparameters. Approaches to creating a training, validation and test sample.	10	
4	LC. Regression and classification models. Linear and logistic regression. Evaluation of models.	2	
	PR. Create regression models of various types, train and evaluate them.	2	
	SR. Support vector machines (support vector machines). Recommendation systems.	10	
5	LC. Machine learning models without a teacher. Features of implementation and metrics.	2	
	PR. Solving clustering problems by the K-means method.	2	
	SR. Other clustering methods (hierarchical clustering, dimensionality reduction by t-SNE, clustering based on DBSCAN density)	12	
6	LC. Decision trees, random forests, and model ensembles.	2	
	PR. Apply and select the best option from different models to a single task.	2	
	SR. Libraries for boosting automation: gradient boosting (xgboost) and high-speed boosting (lightgbm).	12	
7	LC. Natural language processing technologies. The most common approaches and libraries.	2	
	PR. Solving problems of natural language processing.	2	
	SR. Semantic text analysis. Recognizing named entities and finding relationships. POS-tagging.	12	
8	LC. Artificial neural networks. Perceptron. Activation functions. Algorithm for backward error propagation.	2	
	PR. Creation and research of different types of neural networks	2	
	SR. Hybrid neural networks. Neuro-fuzzy networks. Study of genetic algorithms in systems with artificial intelligence. Application of neural networks in machine vision problems.	12	
Together	LC	**16**	
	PR	**16**	
	SR	**88**	

Individual study and research assignment: not provided.

Teaching methods:
1) verbal: 1.1 traditional: lectures, explanations, storytelling, etc;
2) visual: the method of illustrations, the method of demonstrations;
3) practical: 3.1 traditional: practical classes; experiential learning based on computer experiments.

Evaluation system and requirements:

Current performance
1 The current performance of applicants for the performance of educational types of work in classrooms and for the performance of independent work is assessed using a four-point grading scale with the subsequent conversion to a 100-point scale. When assessing current performance, all types of work provided by the curriculum are taken into account.
1.1 Lecture classes are assessed by determining the quality of performance of specific tasks.
1.2 Practical classes are assessed by the quality of the control or individual task, performance and design of practical work.
2 Assessment of the current performance of higher education students is carried out at each practical lesson on a four-point scale ("5", "4", "F", "2") and is recorded in the academic record book.

- "excellent": the applicant has mastered the theoretical material perfectly, demonstrates in-depth knowledge of the relevant topic or discipline, and the main provisions;

- "good": the applicant has mastered the theoretical material well, knows the main aspects from primary sources and recommended literature, presents it reasonably; has practical skills, expresses his/her views on certain problems, but makes certain inaccuracies and errors in the logic of the presentation of theoretical content or in the analysis of practical content;

- "satisfactory": the applicant has basically mastered the theoretical knowledge of the subject or discipline, is familiar with the primary sources and recommended literature, but gives unconvincing answers, confuses concepts, is uncertain about answering additional questions, does not have stable knowledge; when answering practical questions, shows inaccurate knowledge, is unable to evaluate facts and phenomena, and relate them to the future profession;

- "unsatisfactory": the applicant has not mastered the educational material of the topic (discipline), does not know scientific facts, definitions, is almost not familiar with primary sources and recommended literature, lacks scientific thinking, and has not developed practical skills.

3 The final grade for the current activity is recognized as the arithmetic mean of the points for each class, for individual work, and current tests according to the formula:

$$K^{\text{помоч}} = \frac{K1 + K2 + ... + Kn}{n},$$

where $K^{\text{помоч}}$ is the final assessment of success based on the results of the current control;

$K1, K2, ..., Kn$ - Assessment of the success of the n current control measure;

n - number of current control measures.

The scores are converted into points according to the conversion scale (Table 1).

Table 1 - Conversion of the average score for current activities to a multi-point **scale**

4-point scale	100-point scale	4-point scale	100-point scale	4-point scale	100-point scale	4-point scale	100-point scale
5	100	4,45	89	3,90	78	3,35	67
4,95	99	4,4	88	3,85	77	3,3	66
4,9	98	4,35	87	3,80	76	3,25	65
4,85	97	4,3	86	3,75	75	3,2	64
4,8	96	4,25	85	3,7	74	3,15	63
4,75	95	4,20	84	3,65	73	3,1	62
4,7	94	4,15	83	3,60	72	3,05	61
4,65	93	4,10	82	3,55	71	3	60
4,6	92	4,05	81	3,5	70	from 1.78 to 2.99	from 35 to 59
						reassembly	
4,55	91	4,00	80	3,45	69	from 0 to 1.77	from 0 to 34
4,5	90	3,95	79	3,4	68	re-examination	

Final evaluation

1 A higher education student receives a credit at the last class in the discipline based on the results of the current assessment. The average grade for the current activity is converted into points on a 100-point scale, according to the conversion table (Table 1).

Higher education students who have a current average grade in the discipline below "3" (60 points) in the last class can improve their current grade by taking tests in the discipline. Assessment of applicants' knowledge through testing is carried out on a scale:

- "Excellent": at least 90% of correct answers;
- "Very good": 82% to 89% of correct answers;
- "Good": 74% to 81% of correct answers;
- "Satisfactory": 67% to 73% of correct answers;
- "Satisfactory enough": 60% to 66% of correct answers;
- "Unsatisfactory": less than 60% of correct answers.

2 A prerequisite for receiving credit is:

- making up all missed classes;
- the average current grade in the discipline is not lower than "3" (60 points).

3 Additional points are awarded for individual independent work and participation in scientific events.

3.1 Additional points are added to the sum of points gained by the higher education student for the current academic activity (for disciplines for which the final form of control is a test), or to the final grade in the discipline for which the final form of control is an examination.

3.2 The number of additional points awarded for different types of individual tasks depends on their scope and significance:

- prize-winning places in the discipline at the international/national competition of student research papers - 20 points;
- prize-winning places in the discipline at national competitions - 20 points;
- participation in the international/national competition of scientific student works - 15 points
- participation in international/national scientific conferences of students and young scientists - 12 points;
- participation in all-Ukrainian competitions in the discipline - 10 points

- participation in competitions and scientific conferences of KhNADU in the discipline - 5 points;

- completion of individual research (educational and research) tasks of increased complexity - 5 points**.**

3.3 The number of additional points cannot exceed 20 points.

4 The learning outcome is assessed on a two-point scale (pass/fail) according to Table 2; The total score, including additional points, cannot exceed 100 points.

Table 2 - Scale for converting points to the national grading system

On a 100-point scale	**According to the national scale**
from 60 points to 100 points	enrolled
less than 60 points	unaccounted for

Table 3 - Scale for assessing students' knowledge based on the results of the final control in the discipline

Score in points	Score on the national scale		ECTS grade for the course	
	examination	offset	Assessment.	Criteria.
90-100	**Excellent**	**Enrolled**	**A**	The theoretical content of the course has been mastered in its entirety, without gaps, the necessary practical skills to work with the material have been formed, all the learning tasks provided for by the training program have been completed, the quality of their performance has been assessed with a number of points close to the maximum
80-89	**Okay.**	**Enrolled**	**B**	The theoretical content of the course has been mastered in its entirety, without gaps, the necessary practical skills to work with the material have been basically formed, all the learning tasks provided for by the training program have been completed, the quality of most of them has been assessed with a number of points close to the maximum
75-79			**C**	The theoretical content of the course is mastered in full, without gaps, some practical skills of working with the material mastered are insufficiently developed, all the learning tasks provided for by the training program have been completed, the quality of any of them is not assessed with the minimum number of points, some types of tasks are completed with errors

Score in points	Score on the national scale		ECTS grade for the course	
	examination	offset	Assessment.	Criteria.
67-74	**Satisfactory**		**D**	The theoretical content of the course is partially mastered, but the gaps are not significant, the necessary practical skills to work with the material mastered are mostly formed, most of the learning tasks provided for in the training program are completed, some of the completed tasks may contain errors
60-66			**E**	The theoretical content of the course is partially mastered, some practical skills have not been formed, many of the learning tasks provided for in the curriculum have not been completed, or the quality of some of them is assessed with a score close to the minimum.
35-59	**Unsatisfactory**	**Not credited**	**FX**	The theoretical content of the course is partially mastered, the necessary practical skills have not been formed, most of the assignments provided for in the curriculum have not been completed, or the quality of their performance is assessed with a score close to the minimum; with additional independent work on the course material, it is possible to improve the quality of the assignments (with the possibility of retaking)
0-34	**Unacceptable**		**F**	The theoretical content of the course has not been mastered, the necessary practical skills have not been formed, all completed assignments contain gross errors, additional independent work on the course material will not lead to any significant improvement in the quality of the assignments (with a mandatory repeated course)

Course policy:

- The course involves teamwork, and the classroom environment is friendly, creative, and open to constructive criticism;
- mastering the discipline requires mandatory attendance at lectures and practical classes, as well as independent work;
- independent work involves the study of individual topics of the discipline, which are submitted in accordance with the program for independent study, or have been considered briefly;

- all tasks provided for in the program must be completed on time;

- if a higher education student is absent from classes for a valid reason, he/she presents the completed assignments during independent preparation and consultation with the teacher;

- while studying the course, higher education students must adhere to the rules of academic integrity set forth in the following documents: "Rules of Academic Integrity of Participants in the Educational Process of KhNADU" (https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_67_01_dobroch_1.pdf), "Academic Integrity. Checking the text of academic, scientific and qualification works for plagiarism" (https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_85_1_01.pdf), "Moral and ethical code of participants of the educational process of KhNADU (https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_67_01_MEK_1.pdf).

- if the fact of plagiarism is detected, the applicant receives 0 points for the assignment and must repeat the tasks provided for in the silent reading;

- cheating during tests and exams is prohibited (including using mobile devices). Mobile devices are allowed to be used only during online testing.

Recommended reading:

1.1 Bulgakova O. S. Methods and systems of artificial intelligence: theory and practice: a textbook / O. S. Bulgakova, V. V. Zosimov, V. O. Pozdeyev ; Mykolaiv National University named after V. O. Sukhomlynsky - Kherson: OLDI-PLUS, 2020. 353 p.

1.2 Savchenko A.S. Methods and systems of artificial intelligence: a textbook / A.S. Savchenko, O.O. Synelnikov - Kyiv: NAU, 2017. 176 p.

1.3 Intelligent automation systems: a monograph / Avrunin O. G., Vladov S. I., Petchenko M. V., Semenets V. V., Tatarinov V. V., Telnova H. V., Filatov V. O., Shmelev Y. M., Shushlyapina N. O. - Kremenchuk: NOVABUK Publishing House, 2021. 322 p.

Additional

2.1 Subbotin S.O. Representation and processing of knowledge in artificial intelligence and decision support systems: Study guide / S.O. Subbotin. - Zaporizhzhia: ZNTU, 2008. - 341 c.

2.2 Oliynyk A.O. Data mining: a textbook / A.O. Oliynyk, S.O. Subbotin, O.O. Oliynyk - Zaporizhzhia: ZNTU, 2012. -271 p.

2.3 Nikolsky, Y. V. Artificial intelligence systems: a textbook / Y. V. Nikolsky, V. V. Pasichnyk, Y. M. Shcherbyna; under the scientific editorship of V. V. Pasichnyk - Lviv: Magnolia, 2015. 279 p.

2.4 Yampolskyi L.S. Artificial intelligence systems in planning, modeling and management: a textbook for students of higher educational institutions / L.S. Yampolskyi, B.P. Tkach, O.I. Lisovychenko - Kyiv: SE "Publishing house "Personnel", 2011. 544 p.

2.5 Sharov S.V. Intelligent information systems: a textbook / S.V. Sharov, D.V. Lubko, V.V. Osadchyi - Melitopol: B. Khmelnytsky MDPU Publishing House, 2015. 144 p.

Developer
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