Syllabus
of the selective component

Fundamentals of System Identification

Name of the discipline:	**Fundamentals of System Identification**
Higher education level:	**First (bachelor's)**
Course page in Moodle:	https://dl.khadi.kharkov.ua/course/view.php?id=2850
Scope of the educational component	**4 credits (120 hours)**
Form of final control	**Passed**
Consultations:	**on schedule**
Name of the department:	**Department of Metrology and Life Safety**
Language of instruction:	**English**
Course Leader:	**Oleksandr Polyarus, Doctor of Technical Sciences, Professor**
Contact phone:	**+38 096-213-08-89**
Email:	*poliarus.kharkov@ukr.net*

Summary of the educational component:

The goal is to provide students with competence, knowledge, skills and abilities in the basic methods of creating models of technical systems based on input and output actions
Subject*:* theoretical and methodological foundations of identification of technical systems, in particular, measuring information systems and assessment of the quality of created models
The main tasks of studying the discipline are:
− formation of systems of knowledge, skills and ideas about the current state of development of methods of system identification;
− assessment of the possibilities of using identification methods in measuring information systems and road equipment;
− formation of system analysis skills;
− formation of skills for assessing the quality of systems obtained during the identification of system models.
Prerequisites for studying the educational component:
Higher Mathematics, Physical Quantities and Measurements, Theory of Electrical Signals and Circuits, Functional Devices of Measuring Information Systems, Fundamentals of Metrology and Measuring Technology, Introduction to Systems Theory.
Competencies that the applicant acquires:
General competencies:
Ability to apply professional knowledge and skills in practical situations;
Ability to search, process and analyze information from various sources.
Ability to learn and master modern knowledge.
Special (professional) competencies:
Ability to design information and measuring equipment and describe the principle of their operation.
Ability to use modern engineering and mathematical packages to create models of instruments and measurement systems.
Ability to apply standard calculation methods in the design of modules, parts and assemblies of measuring instruments and their computing components and modules.
Learning outcomes:
Be able to find reasonable solutions when drawing up structural, functional and schematic diagrams of information and measuring equipment.

Understand the broad interdisciplinary context of the specialty, its place in theory of cognition and evaluation of objects and phenomena.

Understand the applied methods and methods of analysis, design and research, as well as the limitations of their use.

Thematic plan

Topic No.	Name them (LK, LR, PR, SZ, SR)	Number of hours
		Eye
1	LC The concept of system identification.	2
	PR Identification of systems when reference actions are applied to their input.	2
	SR Basic approaches to system identification.	6
2	LC Main tasks of identification.	2
	PR Identification tasks in the automotive and highway industry.	2
	SR Structural, algorithmic and parametric identification.	6
3	LC The essence of identification experiments.	2
	PR Organization of an identification experiment in a complex system.	2
	SR Active and passive identification.	6
4	LC Statistical identification.	2
	PR Identification by regression analysis.	2
	SR Use in the identification of correlation, factorial, regression and spectral analysis.	6
5	LC Intelligent means of identification.	2
	PR Application of fuzzy identification methods.	2
	SR Comparison of identification by training neural networks and fuzzy identification.	8
6	LC Identification of nonlinear inertial systems.	2
	PR Use of algorithms for identifying nonlinear inertial systems.	2
	SR Wiener and Hammerstein models.	8
7	LC Identification of "black drawer" systems.	2
	PR Evaluation of algorithms for identifying black drawer systems.	2
	SR Basic approaches to the identification of black drawer systems.	8
8	LC Assessment of the quality of system identification.	2

	PR Selection of identification criteria.	2
	SR Types of criteria for identifying systems, their advantages and disadvantages.	8
9	LC Identification of systems with distributed parameters	2
	SR Modeling of diffusion, thermal conductivity processes in the interests of organizing measurements	6
10	LC Identification of systems with incomplete data	2
	SR The problem of observability in the identification of systems	6
11	LC Identification of Multidimensional Systems	2
	SR Modeling of interacting processes	6
12	LC Application of System Identification in Information and Measurement Technologies	2
	SR Analysis of the behavior of models obtained during identification	6
Together	LUX	24
	AVE	16
	WED	80

Individual educational and research task: not provided.

Teaching methods:

MH1 – verbal method (lecture, educational discussion, explanation, story);

MH2 – practical method (practical classes);

MH3 – visual method (method of illustrations, method of demonstrations);

MH4 – work with literature (educational and methodological; normative literature; search for information on the task);

MH5 – video method in combination with the latest information technologies and computer learning tools (distance);

MH6 – independent work;

Forms and methods of assessment

FMO2 – final control (credit)

FMO4 – written control (individual tasks)

FMO5 – test control (standardized tests, final complex tests)

FMO7 – practical test (defense of practical works)

Grading System and Requirements:

Assessment in the discipline and its transfer into grades on the national scale and the ECTS scale is carried out in accordance with STVNZ 90.1-02:2023 "Assessment of the learning outcomes of higher education applicants".

Current Academic Performance

1 The current performance of applicants for the performance of educational types of work in training classes and for the performance of tasks of independent work is evaluated using a four-point scale of assessments with subsequent recalculation in a 100-point scale. When assessing current performance, all types of work provided for by the curriculum are taken into account.

1.1 Lectures are evaluated by determining the quality of performance of specified tasks.

1.2 Practical classes are evaluated by the quality of performance of a control or individual task,

performance and design of practical work.

2 Assessment of the current performance of higher education applicants is carried out at each practical lesson on a four-point scale ("5", "4", "C", "2") and is entered into the journal of academic performance.

– "excellent": applicant has mastered the theoretical material impeccably, demonstrates deep knowledge of the relevant topic or academic discipline, the main provisions;

– "good": the applicant has mastered the theoretical material well, knows the main aspects from primary sources and recommended literature, presents it in a reasoned manner; has practical skills, expresses his thoughts on certain problems, but makes certain inaccuracies and errors in the logic of presenting theoretical content or in the analysis of practical content;

– "satisfactory": the applicant has mainly mastered the theoretical knowledge of an educational topic or discipline, is guided by primary sources and recommended literature, but answers unconvincingly , confuses concepts, uncertainly answers additional questions, does not have stable knowledge; when answering questions of a practical nature, reveals inaccuracy in knowledge, does not know how to evaluate facts and phenomena, associate them with the future profession;

– "unsatisfactory": the applicant has not mastered the educational material of the topic (discipline), does not know scientific facts, definitions, almost does not know the primary sources and recommended literature, there is no scientific thinking, practical skills are not formed.

3 The final score for the current activity is recognized as the arithmetic mean sum of points for each lesson, for individual work according to the formula:

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

where K^{curent} is the final assessment of success based on the results of current control;

$K1, K2, ..., Kn$ – assessment of the success n of the current control measure;

n – the number of current control measures.

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

Table 1 – Recalculation of the average score for current activities into 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	1.78 to 2.99	35 to 59
						Reassembly	
4,55	91	4,00	80	3,45	69	0 to 1.77	0 to 34
4,5	90	3,95	79	3,4	68	Re-study	

Final assessment

1 A higher education applicant receives a credit at the last lesson in the discipline according to 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).

Applicants for higher education Education who have an average Current Assessment with disciplines lower than "3" (60 points), upon Last classes can increase their current score by

taking tests with Discipline.
Assessment of applicants' knowledge by testing is carried out on a scale:
– "Excellent": at least 90% of correct answers;
– "Very good": from 82% to 89% of correct answers;
– "Good": from 74% to 81% of correct answers;
– "Satisfactory": from 67% to 73% of correct answers;
– "Satisfactory enough": from 60% to 66% of correct answers;
– "Unsatisfactory": less than 60% of correct answers.
2 The condition for obtaining The offset is:
– working out all missed Classes;
– average current grade in the discipline not lower "3" (60 points).
3 For the performance of individual independent work and participation in scientific events, applicants are awarded additional points.
3.1 Additional points are added to the sum of points scored by the applicant for higher education for the current educational activity (for disciplines, the final form of control for which is a test), or to the final grade in the discipline, the final form of control for which is an exam.
3.2 The number of additional points awarded for different types of individual tasks depends on their volume and significance:
– prizes in the discipline at the international/all-Ukrainian competition of scientific student works – 20 points;
– prizes in the discipline at the All-Ukrainian Olympiads – 20 points;
– participation in the international/all-Ukrainian competition of scientific student works – 15 points
– participation in international/all-Ukrainian scientific conferences of students and young scientists – 12 points;
– participation in all-Ukrainian Olympiads in the discipline – 10 points
– participation in Olympiads and scientific conferences of KhNAHU in the discipline – 5 points;
– performance 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 evaluated *(choose the one you need):*
– on a 100-point scale (for a differentiated test) according to Table 2.
The final grade, together with additional points, cannot exceed 100 points.

Table 2 – Scale of assessment of applicants' knowledge based on the results of the final control in the academic discipline

Score in points	National scale score		ECTS score	
			Score	Criteria
	Exam	Passed		
90-100	**Perfectly**	**Credited**	**A**	The theoretical content of the course has been mastered completely, without gaps, the necessary practical skills in working with the mastered material have been formed, all the educational tasks provided for by the training program have been completed, the quality of their implementation has been evaluated by the number of points close to the maximum
80–89	**Well**	**Credited**	**B**	The theoretical content of the course is mastered completely, without gaps, the necessary practical skills of working with the mastered material are basically formed, all the educational tasks provided for by the training program are completed, the quality of most of them is evaluated by the number of points close to the maximum

Score in points	National scale score		ECTS score	
	Exam	Passed	Score	Criteria
75-79			**C**	The theoretical content of the course is mastered completely, without gaps, some practical skills of working with the mastered material are not sufficiently formed, all the educational tasks provided for by the training program have been completed, the quality of performance of any of them has not been evaluated by the minimum number of points, some types of tasks have been completed with errors
67-74	**Satisfactory**		**D**	The theoretical content of the course has been partially mastered, but the gaps are not significant, the necessary practical skills in working with the mastered material have been largely formed, most of the educational tasks provided for by the training program have been completed, some of the completed tasks may contain errors
60–66			**And**	The theoretical content of the course has been partially mastered, some practical work skills have not been formed, many of the training tasks provided for by the training program have not been completed, or the quality of some of them has been evaluated by the number of points close to the minimum.
35–59	**Disappointing**	**Not Credited**	**FX**	The theoretical content of the course has been partially mastered, the necessary practical skills have not been formed, most of the provided training programs for educational tasks have not been completed, or the quality of their implementation has been evaluated by the number of points close to the minimum; With additional independent work on the course material, it is possible to improve the quality of educational tasks (with the possibility of re-compiling)
0–34	**Unacceptable**		**F**	The theoretical content of the course has not been mastered, the necessary practical skills have not been formed, all completed training tasks contain gross errors, additional independent work on the course material will not lead to any significant improvement in the quality of educational tasks (with the obligatory repeated course)

Recognition of the results of non-formal and informal education

The procedure for recognizing learning outcomes obtained in non-formal and informal education is regulated by STVNZ-83.1-02:2022 "Recognition of the results of non-formal and informal education".

To recognize such results, it is necessary to apply to the dean of the faculty with a corresponding application and attach certificates, certificates and other documents confirming the received competencies. Based on the results of consideration of the application, a subject commission is created, which considers the submitted documents, conducts an interview with the applicant and makes a decision on the re-enrollment of the learning results or the appointment of certification in the form of a final control (10 working days are given for preparation). Based on the results of the control, the commission gives a final grade. If the applicant received less than 60 points, then the results of learning in non-formal or informal education are not counted. When re-enrolling the results of training in the discipline, the applicant is exempt from its study. **Course Policy:**

– the course involves teamwork, the environment in the classroom is friendly, creative, open to constructive criticism;

– mastering the discipline involves mandatory attendance at lectures and practical classes, as well as independent work;

– independent work involves the study of individual topics of the academic discipline, which are submitted in accordance with the program for independent study, or were considered briefly;

– all tasks provided for by the program must be completed on time;

– if the applicant for higher education is absent from classes for a good reason, he/she presents the completed tasks during self-preparation and consultation with the teacher;

– during the study of the course, applicants for higher education must comply with the rules of academic integrity set forth in the following documents: "Rules of academic integrity of participants in the educational process of KhNAHU" (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 papers for plagiarism" (https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_85.1-02.pdf), "Moral and ethical code of participants in the educational process of KhNAHU (https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_67_01_MEK_1.pdf).

– in case of detection of the fact of plagiarism, the applicant receives 0 points for the task and must re-complete the tasks provided for in the syllabus;

– cheating during tests and exams is prohibited (including the use of mobile devices). Mobile devices are allowed to be used only during online testing.

Recommended reading:

1. Polyarus O. V., Koval O. A., Medvedovska Y. S., Polyakov E. O., Yanushkevych S. D. Identification of a nonlinear inertial measuring pressure channel. – Ukrainian Metrology Journal, 2019, No. 1, pp. 63-70.

2. Hugues Garnier. Data-driven system identification for control. – Polytech Nancy, 2024. - 10 p.

3. Qinghua Zhang. Nonlinear System Identification: An Overview of Common Approaches. – Springer, 2021, pp. 1492–1502

4. Gerardus Blokdyk. System Identification. A Complete Guide. - 5STARCooks, 2021. – 304 p.

5. I. L. Levchuk, G. I. Manko, V. Y. Trishkin, V. I. Korsun. Theory and practice of identification of objects of management. – Dnipro, 2019. – 205 p.

Additional sources:

1. Distance course. Access mode: https://dl2022.khadi-kh.com/course/view.php?id=2850

2. Underactuated Robotics. 2024. https://underactuated.mit.edu/misc.html

3. System Identification in Matlab, 2022. https://www.mathworks.com/help/ident/gs/about-system-identification.html

4. Antonio Ferramosca. Introduction to systems identification. - University of Bergamo, 2023. – 69 p. https://cal.unibg.it/wp-content/uploads/DSI/slide/Lecture-18-Identification.pdf

5. Ingvar Ziemann,Anastasios Tsiamis,Bruce Lee,Yassir Jedra,Nikolai Matni,George J. Pappas. A Tutorial on the Non-Asymptotic Theory of System Identification, arXiv:2309.03873, 2023. https://doi.org/10.48550/arXiv.2309.03873

Developer
syllabus of the academic discipline _____ Polyarus O. V.
signature

Head of the Department _____ Bogatov O. I.
signature