Syllabus
of educational component

Fundamentals of system identification

Discipline name:	**Fundamentals of system identification**
Higher education level:	**second (master's)**
Course page in Moodle:	**https://dl.khadi.kharkov.ua/course/view.php?id=2850**
The scope of the educational component:	**4 credits (120 hours)**
Final control form:	**Test**
Consultations:	**according to the schedule**
Name of the department:	**department of metrology and life safety**
Teaching language:	**English**
Head of the course:	**Oleksandr Poliarus, Doctor of Eng. Science., professor**
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Brief content of the educational component:

The goal is for applicants to acquire competence, knowledge, abilities and skills 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, measurement information systems and assessment of the quality of created models.
The main tasks of studying the academic discipline are:
- formation of systems of knowledge, skills and ideas about the current state of development of systems identification methods;
− assessment of the possibilities of applying identification methods in measuring information systems and road engineering;
- formation of system analysis skills;
- formation of quality assessment skills obtained during the identification of system models.

Prerequisites for studying the educational component:
Metrology and measuring equipment, Introduction to systems theory, Dynamic characteristics of measuring equipment.
Competencies that the student acquires:

General competences:

Ability to apply professional knowledge and skills in practical situations;
Ability to search, process and analyze information from various sources
Skills in using information and communication technologies
Ability to evaluate and ensure the quality of work.

Special (professional) competences:

The ability to analyze error components according to their essential features, operate with error/uncertainty components in accordance with measurement models.
Ability to design information and measurement equipment and describe the principle of their operation.
Ability to use modern engineering and mathematical packages to create models of instruments and measurement systems.

The ability to apply standard calculation methods when designing modules, parts and units of measuring equipment and their computing components and modules.

Ability to perform technical operations during testing, verification, calibration and other operations of metrological activity.

The ability to measure the parameters of automobile and road equipment and process their results.

Learning results:

To be able to find reasonable solutions when drawing up structural, functional and principle diagrams of information and measurement equipment.

Know and understand the basic concepts of metrology, measurement theory, mathematical and computer modeling, modern methods of processing and assessing the accuracy of a measurement experiment.

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

Topical plan

№ of the topic	Name of topics (lectures, laboratory works, practical lessons, independent work)	Number of hours	
		full-time	correspondence
1	LC The concept of system identification.	2	2
	PL Identification of systems when supporting actions are submitted to their input.	2	2
	IW Basic approaches to system identification.	12	14
2	LC Basic tasks of identification.	2	-
	PL Identification problems in the automobile and road industry.	2	-
	IW Structural, algorithmic and parametric identification.	12	-
3	LC The essence of identification experiments.	2	-
	PL Organization of an identification experiment in a complex system.	2	-
	IW Active and passive identification.	12	14
4	LC Statistical identification.	2	-
	PL Identification by regression analysis.	2	-
	IW Use of correlational, factorial, regression and spectral analysis in identification.	12	14
5	LC Intelligent means of identification.	2	-
	PL Application of fuzzy identification methods.	2	-
	IW Comparison of identification by learning neural networks and fuzzy identification.	12	14

6	LC Identification of nonlinear inertial systems.	2	-
	PL Use of algorithms for identification of nonlinear inertial systems.	2	-
	IW Models of Wiener and Hammerstein.	12	14
7	LC Identification of "black box" type systems.	2	-
	PL Evaluation of algorithms for the identification of "black box" type systems.	2	-
	IW The main approaches to the identification of systems of the "black box" type.	8	14
8	LC Evaluation of the quality of system identification.	2	2
	PL Choice of identification criteria.	2	2
	IW Types of system identification criteria, their advantages and disadvantages.	8	14
Разом	LC	16	4
	PL	16	4
	IW	88	112

Individual educational and research task (if available):

Carry out system identification in the form of a simple electronic circuit.

Teaching methods:

1) verbal: 1.1 traditional: lectures, explanations, stories, etc.;

1.2 interactive (non-traditional): problem lectures, discussions, etc.;

2) visual: method of illustrations, method of demonstrations;

3) practical: 3.1 traditional: practical classes, seminars;

3.2 interactive (non-traditional): trainings, brainstorming method.

Knowledge assessment system and requirements:

Current success rate

1 The current success of applicants for the performance of educational types of work in training classes and for the performance of independent work tasks is evaluated using a four-point rating scale with subsequent transfer to a 100-point scale. During the evaluation of the current academic performance, all types of work provided by the educational program are taken into account.

1.1 Lecture classes 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 The evaluation of the current academic performance of students of higher education is carried out at each practical session on a four-point scale ("5", "4", "Z", "2") and is entered in the journal of academic performance.

– “excellent”: the applicant mastered the theoretical material flawlessly, demonstrates deep knowledge of the relevant topic or academic discipline, the main provisions;

- "good": the applicant has mastered the theoretical material well, has the main aspects from primary sources and recommended literature, presents it in a reasoned way; has practical skills, expresses his thoughts on certain problems, but certain inaccuracies and errors are assumed in the logic of the presentation of theoretical content or in the analysis of practical ones;
- "satisfactory": the applicant has basically mastered the theoretical knowledge of the educational topic or discipline, orients himself in primary sources and recommended literature, but answers unconvincingly, confuses concepts, answers additional questions uncertainly, 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, connect them with the future profession;
- "unsatisfactory": the applicant has not mastered the educational material of the topic (discipline), does not know scientific facts, definitions, hardly orients himself in primary sources and recommended literature, lacks scientific thinking, practical skills are not formed.

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

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

where $K^{current}$ – final evaluation of success based on the results of current control; $K1, K2, ..., Kn$ – evaluation of the success of the n current control measure;

n – the number of measures of current control.

Estimates are converted into points according to the conversion scale (table 1).

Table 1 – Recalculation of the average grade for the current activity 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	from 1,78 to 2,99	from 35 to 59
						retaking	
4,55	91	4,00	80	3,45	69	від 0 до 1,77	від 0 до 34
4,5	90	3,95	79	3,4	68	repeated study	

Final assessment

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

Applicants for higher education who have a current grade point average in the discipline lower than "3" (60 points) can increase their current grade by taking tests in the discipline in the last session.

Assessment of the knowledge of applicants through testing is carried out according to the following 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 credit is:
- making up for all missed classes;
– the average current grade in the discipline is not lower than "3" (60 points).

3 For performing individual independent work and participating in scientific events, winners are awarded additional points.

3.1 Additional points are added to the sum of points scored by the student of higher education for the current educational activity (for disciplines for which the final form of control is a credit), or to the final grade in the discipline for which the final form of control 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;
- prize places 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 the Khnadu in the discipline - 5 points;
- performance of individual scientific and research (educational and research) tasks of increased complexity - 5 points.

3.3 The number of additional points cannot exceed 20 points.

4 The learning result is evaluated on a two-point scale (passed/failed) according to table 2;
The final grade together with additional points cannot exceed 100 points.

Table 2 – Scale of transfer of points to the national assessment system

On a 100-point scale	**On a national scale**
from 60 points to 100 points	credited
less than 60 points	not credited

Table 3 - Scale for assessing the knowledge of applicants for the results of final control of academic discipline

Score in points	Evaluation according to the national scale		Evaluation according to the ECTS scale	
			Estimation	Criteria
	екзамен	залік		
90-100	**Excellent**	**Credited**	**A**	The theoretical content of the course has been mastered in its entirety, without gaps, the necessary practical skills for working with the mastered material have been formed, all educational tasks provided for in the training program have been completed, the quality of their performance has been assessed with a number of points close to the maximum

Score in points	Evaluation according to the national scale		Evaluation according to the ECTS scale	
			Estimation	Criteria
	екзамен	залік		
80–89	**Good**	**Credited**	**B**	The theoretical content of the course has been mastered in its entirety, without gaps, the necessary practical skills for working with the mastered material have mainly been formed, all educational 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 has been mastered in its entirety, without gaps, some practical skills of working with the mastered material have not been formed enough, all educational tasks provided for by the training program have been completed, the quality of none of them has been assessed with a minimum number of points, some types of tasks have been completed with errors
67-74	**Satisfactorily**		**D**	The theoretical content of the course is partially mastered, but the gaps are not of a significant nature, the necessary practical skills for working with the mastered material are basically formed, most of the educational tasks provided by the training program have been completed, some of the completed tasks may contain errors
60–66			**E**	The theoretical content of the course has been partially mastered, some practical work skills have not been formed, many educational tasks provided by the training program have not been completed, or the quality of some of them has been assessed with a number of points close to the minimum.
35–59	**Unsatisfactorily**	**Not credited**	**FX**	The theoretical content of the course has been partially mastered, the necessary practical work skills have not been formed, most of the prescribed training programs of educational tasks have not been completed, or the quality of their implementation has been assessed with a number of points close to the minimum; with additional independent work on the course material, it is possible to improve the quality of the performance of educational tasks (with the possibility of retaking)

Score in points	Evaluation according to the national scale		Evaluation according to the ECTS scale	
	екзамен	залік	Estimation	Criteria
0–34	**Unacceptable**		**F**	The theoretical content of the course has not been mastered, the necessary practical work skills have not been formed, all completed educational tasks contain gross errors, additional independent work on the course material will not lead to any significant improvement in the quality of the performance of educational tasks (with a mandatory repeat course).

Course policy:

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

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

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

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

- if the student of higher education is absent from classes for a good reason, he presents the completed tasks during independent preparation and consultation of the teacher;

- while studying the course, students of higher education 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 the 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 works for plagiarism" (https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_85_1_01.pdf), "Moral and ethical code of participants in the educational process of the KhNAHU (https://www.khadi.kharkov.ua/fileadmin/P_Standart/pologeniya/stvnz_67_01_MEK_1.pdf).

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

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

Recommended literature: (literature no later than 10 years old, except for 1 fundamental classical textbook or monograph)

1. Leung L. Identification of systems. Theory for the user: Trans. with English./Under the editorship. Ya. Z. Tsypkina - M.: Nauka, 1991. - 432 p.
2. Dubovoi V. M. Identification and modeling of technological objects and control systems: training. manual. – Vinnytsia, VNTU, 2012. – 308 p.
3. Poliarus O. V., Koval O. A., Medvedovska Ya. S., Polyakov E. O., Yanushkevich S. D. Identification of a nonlinear inertial measuring pressure channel. – Ukrainian Metrological Journal, 2019, No. 1, p. 63-70.
4. Prateek Mishra, Avinash Giri. Review of system identification using neural network techniques. - International Journal of Electrical, Electronics and Data Communication, Volume-2, Issue-7, July-2014, pp. 13-16.

5. Poliarus O. V., Poliakov E. O. Approximate solution of the inverse measurement problem and its metrological support. - Monograph. - Kh.: "Leader" publishing house, 2014. - 120 p.
6. Koval A. V. Identification and modeling of technological objects. - Zhytomyr, Zhdtu, 2018. - 133 p.
7. Pavlenko I.V., Simonovskyi V.I. Methods of identifying parameters of mathematical models of oscillatory processes. - Monograph. – Sumy, SDU, 2020. – 145 p.

Additional sources:

1. distance course: https://dl.khadi.kharkov.ua/course/view.php?id=2850
2. https://lutsk-ntu.com.ua/sites/default/files/06_norma_0.pdf
3. https://journal-me.com/archive-ukr/vol23-2020-iss2-paper2/?print=print
4. https://studopedia.org/12-99505.html
5. http://mcm-tech.kpnu.edu.ua
6. https://journals.indexcopernicus.com/api/file/viewByFileId/683129.pdf
7. http://www.numdam.org/item/COCV_2013__19_1_190_0/
8. https://iopscience.iop.org/article/10.1088/0957-0233/9/6/001
9. https://uwaterloo.ca/waterloo-laboratory-for-inverse-analysis-and-thermal-sciences/research/inverse-problem

Developer

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