

## Syllabus of the educational component ED

### Automatic control theory

Course name:	<b>Automatic control theory</b>
Level of higher education:	<b>first (bachelor's)</b>
Course page in Moodle:	<a href="https://dl2022.khadi-kh.com/course/view.php?id=2622">https://dl2022.khadi-kh.com/course/view.php?id=2622</a>
The amount of the educational component	<b>4 credits (120 hours)</b>
Final control form	<b>test</b>
Consultations:	<b>According to schedule</b>
Name of the department:	<b>department of automation and computer-integrated technologies</b>
Teaching language:	<b>Ukrainian, English</b>
Course leader:	<b>Oleksandr Gurko, DrSci, professor</b>
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#### **Brief content of the discipline:**

**The purpose** of the discipline is to form the student's theoretical and practical knowledge in the field of creation and functioning of systems of automatic control of technical objects, and the ability to perform analysis and Design of such systems.

**Subject:** a pedagogically adapted system of concepts about the laws of automatic control and methods of their application.

#### **The main tasks of the educational are:**

- studying the basic principles of automatic control systems;
- formation of skills in mathematical modelling of automatic control systems;
- formation of skills of stability and performance analysis of automatic control systems;
- formation of skills for choosing the type of controller and determining the values of its parameters;
- formation of skills in the use of specialized software for solving typical problems in the analysis and Design of automatic control systems.

#### **Prerequisites for studying the educational component:**

Higher mathematics  
Physics  
Theoretical mechanics  
Electrical engineering and electromechanics  
Algorithmizing and programming or computer science.

#### **Competencies acquired by the student:**

##### **General competences:**

Ability to apply knowledge in practical situations.  
Ability to communicate in the national language both orally and in writing.  
Skills in using information and communication technologies.  
Ability to search, process and analyse information from various sources.  
Ability to work in a team.

##### **Special (professional) competences:**

Ability to solve practical problems using methods of mathematics, physics and electrical engineering.

Ability to analyse automation objects based on knowledge of the processes that occur in them and apply methods of automatic control theory to study, analyse and synthesize automatic control systems.

Ability to apply mathematical modelling, identification and numerical methods to develop mathematical models of individual elements and automation systems as a whole, to analyse the quality of their functioning using the latest computer technology.

Ability to freely use modern computer and information technologies to solve professional problems, program and use applied and specialized computer-integrated environments.

### Learning outcomes according to the educational program:

Understand the essence of the processes occurring in automation objects and be able to analyse automation objects and justify the choice of structure, algorithms, and control schemes based on the results of the study of their properties.

To be able to apply the methods of automatic control theory for the study, analysis, and synthesis of automatic control systems.

Be able to apply modelling, identification, and numerical methods to develop mathematical and simulation models of individual elements and automation systems as a whole, to analyse the quality of their functioning using the latest computer technology.

Be able to use a variety of specialized software to solve typical engineering problems in the field of automation.

### Thematic plan

Theme No	Name of themes (LEC, PW, SS)	Number of hours	
		full-time	extramural
1	2	3	4
1	LEC. Basic concepts of automatic control systems. Classification of control systems.	2	
	PW. Basics of MATLAB and Simulink.	2	
	SS. History of automatic control systems. Vectors and matrices in MATLAB. Graphs plotting in MATLAB.	8	
2	LEC. Mathematical modelling of linear systems.	6	
	PW. Differential equations of ACS elements, their linearization and solution in Simulink.	4	
	Transfer functions, transient and frequency responses in MATLAB.	2	
	SS. Differential equations of hydraulic systems. Analytical building of transient characteristics. Asymptotic Bode plots. Types of filters. Real integrating and differentiating links. 2nd order aperiodic link.	10	
3	LEC. Stability of linear continuous control systems.	4	
	PW. Study of control systems stability and root locus.	2	
	Study of control systems stability according to Hurwitz and Nyquist criteria.	2	
	SS. Routh criterion. Proof of the Nyquist criterion. Stability of systems described in the space of states.	8	
4	LEC. Control systems performance.	6	
	PW. Studying control systems performance in MATLAB.	2	
	SS. The impact of the 3rd pole and zero on the characteristics of the 2nd order system. Sensitivity of a control system to changing in parameters. Quadratic cost functions which take into account energy consumption for control.	10	

1	2	3	4
5	LEC. Design of linear continuous control systems.	6	
	PW. Design of P, PI and PID controllers in MATLAB.	8	
	SS. Disadvantages of PID controllers. Integral saturation. Frequency characteristics of PID. Design of PID using frequency responses.	10	
6	LEC. Discrete control systems	8	
	PW. Simulation of discrete control systems in MATLAB. Design of discrete controllers in MATLAB.	4 6	
	SS. Description of discrete systems in the space states. Root locus of digital control systems. The Schur-Cohn criterion.	10	
Total	Lectures	32	
	Practical works	32	
	Self-study	56	
<b>Total for course</b>		<b>120</b>	

**Individual educational and research task:** not provided.

### 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.

### Evaluation system and requirements:

#### Current performance

**1** The current success of applicants for the performance of educational types of work in training sessions 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 for 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.

**1.3** Laboratory classes are evaluated by the quality of reports on the performance of laboratory work.

**1.4** Seminar classes are evaluated by the quality of individual assignment/abstract.

**2** The current performance of higher education applicants is assessed at each practical session (laboratory or seminar) on a four-point scale ("5", "4", "3", "2") and entered in the journal of academic performance.

– "excellent": the winner 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 recognized as the arithmetic mean sum of points for each lesson, for individual work, current test works according to the formula:

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

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

$K1, K2, \dots, Kn$  – evaluation of the success  $n$  of the current control measure;

$n$  - the number of measures of current control.

Assessments are converted into points according to the calculation scale (table 1).

**Table 1** – Recalculation of the average grade for the current activity into a multi-point scale

4-point scale	100 points scale	4-ball scale	100 points scale	4-ball scale	100 points scale	4-ball scale	100 points 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	repeated study	

### Final assessment

**1** The exam is held after studying all topics of the discipline and is completed by students of higher education during the examination session after the end of all classroom classes

**2** Students of higher education who have completed all types of work prescribed by the curriculum in the discipline are admitted to the exam:

- were present at all classroom classes (lectures, seminars, practical);
- completed all missed classes on time;
- scored the minimum number of points for the current academic performance (at least 36 points, corresponding to the national scale "3");

If the current success in the discipline is lower than 36 points, the higher education applicant has the opportunity to increase his current point to the minimum before the beginning of the examination session.

**3** Assessment of the knowledge of applicants when taking the exam is carried out on a 100-

point scale.

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.

**4** The final grade for the academic discipline is defined as a weighted average grade that takes into account the overall grade for the current academic performance and the grade for passing the exam.

**5** The calculation of the overall final grade for the study of an academic discipline is carried out according to the formula:

$$PK^{fin} = 0,6 \cdot K^{current} + 0,4 \cdot E,$$

where  $PK^{fin}$  is the final assessment of success in disciplines, the form of final control for which is an exam;

$K^{current}$  – final assessment of success based on the results of current control (on a 100-point scale);

$E$  - grade based on the results of the exam (on a 100-point scale).

0.6 and 0.4 are coefficients for the ratio of points for current success and passing the exam.

**6** For performing individual independent work and participation in scientific events, additional points are awarded to the winners.

**6.1** 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 test), or to the final grade in the discipline for which the final form of control is an exam.

**6.2** The number of additional points awarded for different types of individual tasks depends on their volume and importance:

- 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 KhNAHU in the discipline - 5 points;
- performance of individual scientific and research (educational and research) tasks of increased complexity - 5 points .

**6.3** The number of additional points cannot exceed 20 points.

**7** The total final grade for studying an academic discipline cannot exceed 100 points.

The overall final grade for the study of the academic discipline is determined according to the scale given in Table 2.

**Table 2** – The scale for evaluating the knowledge of the students based on the results of the final control of the academic discipline

Score in points	Evaluation on a national scale		ECTS scale	
			Rating	Criteria
	examination	test		
90-100	Perfectly	Passed	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
80-89	Good	Passed	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			WITH	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.

Score in points	Evaluation on a national scale		ECTS scale	
			Rating	Criteria
	examination	test		
<b>35–59</b>	<b>Unsatisfactorily</b>	<b>Not passed</b>	<b>FX</b>	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)
<b>0–34</b>			<b>F</b>	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 presented in accordance with the program for independent study, or were considered briefly;
- all tasks provided 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;
- the coursework must be protected no later than a week before the beginning of the examination session;
- while studying the course, students of 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 the KhNAHU" ([https://www.khadi.kharkov.ua/fileadmin/P\\_Standart/pologeniya/stvnz\\_67\\_01\\_dobroch\\_1.pdf](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\\_01.pdf](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](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 Books:**

1. Nise N.S. Control System Engineering. 8th edition. John Wiley & Sons, 2015. 944p.
2. Richard C., Dorf, and Robert H. Bishop. Modern control systems. Pearson Prentice Hall, 2008.
3. Nagrath I. J., Gopal M. Control Systems Engineering. 6th edition. New age international publishers, 2017.

**Additional sources:**

1. System Modeling: Control Tutorials for MATLAB&Simulink. [Electronic source] - Access mode: <http://ctms.engin.umich.edu/CTMS>.
2. Engineering Media [Electronic source]. – Access mode: <https://engineeringmedia.com>
3. MATLAB and Simulink Videos. [Electronic source]. – Access mode: <https://www.mathworks.com/videos.html>

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