National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Department of Electromechanical Systems Automation and Electrical Drives

Course Work in Automatic Control Theory

Working program of the academic discipline (Syllabus)

Props academic discipline

Level of higher education	***First (undergraduate)***
Discipline	*14 "Electrical engineering"*
Specialty	*141 "Electric power engineering, electrical engineering and electromechanics"*
Educational program	*Electromechanical automation systems, electric drive and electromobility*
Discipline status	*Normative*
Form of education	*Daytime*
Year of training, semester	*2nd course, spring semester*
Scope of the discipline	*30 hours / 1 ECTS credit*
Semester control/ control measures	*Test*
Class schedule	*http :// rozklad . kpi ua / Schedules / ViewSchedule . aspx ? v = fcdd 26 a 5-1 e 05-452 c - bab 5-0604 b 5 d 84 a 4 f*
Language of teaching	*Ukrainian*
Information about the course leader / teachers	*Doctor of Science, Professor, Tolochko Olga Ivanivna, tel. 0994945473*
Placement of the course	*https://classroom.google.com/c/Mzc4Njk0NTQzMTA0*

Program of study discipline

1. Description of the educational discipline, its purpose, subject of study and learning outcomes

Syllabus of the academic discipline "Theory of automatic control. The coursework" was compiled in accordance with the educational and professional program "Electromechanical systems of automation, electric drive and electromobility" of bachelor's training in the field of knowledge 14 "Electrical engineering" in the specialty 141 "Electric power engineering, electrical engineering and electromechanics".

The purpose of the educational discipline *is formation and strengthening of students' following abilities: (K01) Ability to abstract thinking, analysis and synthesis; (K03) Ability to communicate in the state language both orally and in writing; (K04) Ability to communicate in a foreign language; (K05) Ability to search, process and analyze information from various sources; (K08) Ability to work autonomously; (FK01) Ability to solve practical problems using automated design and calculation systems (CAD); (FK02) Ability to solve practical problems involving the methods of mathematics, physics and electrical engineering; (FC12) Ability to use mathematical methods and methods of automatic control theory in the study of linear and non-linear systems, analyze quality indicators, synthesize regulators, compile and analyze structural diagrams of automatic control systems ; (FC13) Ability to use modeling software packages for analysis, synthesis and research of electromechanical automation systems and electric drives.*

The subject of the academic discipline *– equivalent transformations of structural schemes; determination of zeros, poles, amplification factor, Q-factor by speed, transition and weighting functions from transfer functions; analysis of linear continuous automatic control systems (LACS) in*

time space, construction of frequency characteristics and frequency analysis; verification of SAC for stability and determination of stability reserves; analysis based on the location of pole zeros on the complex plane; mathematical description of SAC in the space of states; formation of standard characteristic polynomials; synthesis of the modal regulator.

Program learning outcomes that the discipline aims to improve: *(PRN06) Apply application software, microcontrollers and microprocessor technology to solve practical problems in professional activities ; (PRN08) Choose and apply suitable methods for the analysis and synthesis of electromechanical and electric power systems with specified indicators; (PRN10) Find the necessary information in scientific and technical literature, databases and other sources of information, evaluate its relevance and reliability; (PRN11) Communicate freely about professional problems in national and foreign languages orally and in writing, discuss the results of professional activity with specialists and non-specialists, argue one's position on debatable issues; (PRN18) To be able to learn independently, acquire new knowledge and improve the skills of working with modern equipment, measuring equipment and application software; (PRN20) Know and understand the principles of control of linear, non-linear and discrete automatic control systems; mathematical methods in electromechanics; (PRN26) To know and understand the laws of transformation of structural schemes, typical control laws, methods of studying the stability of linear automatic control systems; typical libraries of Simulink blocks, basics of programming in M-files.*

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

The prerequisite for completing the coursework in the academic discipline "Theory of automatic control. Course work" is the study of the disciplines "Higher mathematics", "Computing technology and programming". The course work is performed simultaneously with the study of the discipline "Theory of automatic control". The credit module "Theory of automatic control. Course work" provides training in the disciplines "Modeling and analysis of electromechanical systems in MATLAB ", "Control of electric drives", "Fundamentals of mechatronics" for the 1st (bachelor's) level, as well as "Intelligent control and optimization in electromechanical systems" and "Robust control" for the 2nd (master's) level.

3. Content of the academic discipline

*The following tasks are solved **in the discipline :***

1. *Checking the functionality of the regulation object specified for research by the method of mathematical modeling.*
2. *Equivalent transformation of structural schemes and determination of transfer functions of the system by task and disturbance in polynomial form. Calculation of steady-state values of transient functions and steady-state values of adjustment error. Comparing them with the results of modeling in item 1.*
3. *Decomposition of transfer functions in polynomial form into factors (sequential decomposition). Determination of dominant poles. Analysis of systems by location of zero-poles and determination of stability.*
4. *Transformation of the transfer function by control into the sum of elementary fractions (parallel decomposition). Analytical definition of the transition function.*
5. *Mathematical description of the studied system in the space of states.*
6. *Frequency analysis of the object under study and determination of stability reserves from the Bode and Nyquist diagrams of the open system.*
7. *Analysis of systems in time space and determination of quality indicators of transient processes.*
8. *Comparison of exact and approximate quality indicators. Formulation of conclusions to the work.*
9. *Designing a term paper and submitting it for review.*

10. Protection of term paper.

4. Educational materials and resources

Main information resources:

1. Popovych M.G., Kovalchuk O.V. Theory of automatic control. - K.: Lybid, 2007.– 656p.

2. Theory of automatic control: method. instructions for coursework in the discipline / NTUU "KPI"; structure. O. I. Tolochko, B. I. Pryimak, S. M. Peresada. - Kyiv: NTUU "KPI", 2022. - 167 p.

Additional:

3. Ogata K. Modern control engineering, Prentice-Hall, 2010, 905 p.

4. Phillips C., Harbor R. Feedback control systems, Prentice-Hall, 2000, 658 p.

Educational content

5. Methods of mastering an educational discipline (educational component)

Each student is provided with initial data for course work.

During course work, students must:

1. *Check the operability and stability of the regulation object set for research by mathematical modeling in the Simulink environment .*
2. *Perform equivalent transformations of structural diagrams and determine the transfer function of the open system and the transfer functions of the closed system by task and disturbance in polynomial form. Compare the results of transformations performed according to analytical formulas with the results obtained by using the tools of the MATLAB package . Calculate the steady-state values of the transient functions and the steady-state values of the regulation error and Q-factor by speed.*
3. *Construct the transition and weight functions of the system under control and under disturbance and the response of the system to a linear signal with a unit coefficient using the tools of the MATLAB package . Determine the type of processes and indicators of the quality of transient processes.*
4. *Decompose the control transfer function to the external feedback signal in polynomial form into factors (sequential decomposition). Determine zeros, poles and their characteristics, build a map of the location of zeros-poles on the complex plane, draw a conclusion about the stability of the system. Determine the dominant pair of complex-conjugate poles (or the dominant real pole). To analyze the quality of transient processes according to the location of pole zeros. Compare the results of the analysis with the parameters of the transition function by control.*
5. *Transform the transfer function by control into the sum of elementary fractions (parallel decomposition). Determine the transition function analytically. Compare the transient function calculated by the analytical expression with the transient function obtained using MATLAB functions .*
6. *Perform a mathematical description of the studied system in the space of states. Find the characteristic polynomial from it, calculate the constant values of the state variables and the output variable. Determine controllability and observability of the system.*
7. *Perform a frequency analysis of the object under study and determine the stability reserves from the Bode and Nyquist diagrams of the open system. Construct an asymptotic logarithmic amplitude-frequency characteristic of an open system and determine from it approximate indicators of the quality of transient processes of a closed system*
8. *Compare exact and approximate quality indicators. Formulate conclusions for work.*

6. Student's independent work

No. z/p	Type of independent work	Number hours of SRS	Deadline
1	Obtaining a topic and assignment for a term paper	1	3rd week
2	Development of Simulink - models of the studied system	3	4th week
3	Equivalent transformations of the system and search for its transfer functions. Determination of static indicators.	4	6th week
4	Construction of transitional and weighting functions and system response to a linear signal. Determination of quality indicators of transient processes	3	8th week
5	Construction of maps of the location of zeros and poles on the complex plane, determination of system stability. Approximate analysis of the quality of transient processes.	3	9th week
6	Analytical definition of the transition function by control	3	10th week
7	Mathematical description of the system in the space of states. Definition of controllability and observability.	3	11th week
8	Construction of frequency response and frequency response of a closed system, construction of graphs of the system's response to sinusoidal influences. Construction of Bode and Nyquist diagrams of an open system, asymptotic LACH of an open system. Determination of stability reserves.	4	14th week
9	Completing the coursework and submitting it for review	4	16th week
10	Preparation for the defense and defense of the course work	2	17th, 18th weeks
	Together	30	

Policy and control

7. Policy of academic discipline (educational component)

The system of requirements that the teacher sets before the student :

- *rules for attending classes: in accordance with Order 1-273 dated 14.09.2020, it is prohibited to evaluate the presence or absence of the winner at the classroom class, including the awarding of incentive or penalty points. In this discipline, there are not classroom classes, but consultations, the attendance of which is desirable and useful for the student, but the teacher does not award incentive or penalty points for attendance or absence from consultations. According to the RSO of this discipline, points are awarded for the quality of the explanatory note, compliance with the coursework schedule during the semester, and the defense of the coursework. Timely submission of the term paper is a mandatory condition for admission to its defense;*
- *rules of conduct at consultations: the student has the opportunity to receive points for the appropriate types of educational activity at consultations, provided for by the RSO of the discipline. The use of means of communication to search for information on the teacher's Google Drive, on the Internet, in a distance course on the Sikorsky platform is carried out on the condition that the teacher instructs;*

- *students are obliged to regularly view messages in Google-class and promptly respond to them;*
- *in the case of distance learning, students should upload coursework sections to Google-class in time for preliminary checking and early detection of errors;*
- *policy of deadlines and rescheduling: non-compliance with the coursework schedule involves a reduction in the number of points on the starting scale in accordance with the RSO; if there are errors in the corresponding task of the coursework, this task can be returned for revision, but at the same time, the date of submission is considered the date of submission of the completed task; in order to be admitted to the defense of the course work, students must submit the completed course work five days before the appointed date of the defense and fulfill other conditions of admission, otherwise the student will not be allowed to defend the work; re-defense of the course work is carried out after the end of the main session, provided that the course work is passed and the conditions of admission are met ;*
- *coursework defense rules: only individual defense is allowed.*
- *rules for assigning incentive points: incentive points are not included in the main scale of RSO, and their sum does not exceed 10% of the starting scale. Incentive points are awarded for participation in faculty and institute Olympiads, participation in faculty and institute scientific conferences;*
- *policy on academic integrity: the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical behavior of individuals and provides a policy of academic integrity for persons working and studying at the university, which they should be guided by in their activities, including when studying and preparing control measures in the discipline "Theory of automatic control. Course work";*
- *when using digital means of communication with the teacher (mobile communication, e-mail, correspondence in the Google Classroom environment), it is necessary to observe generally accepted ethical norms, in particular, be polite and limit communication to the working hours of the teacher.*

8. Types of control and rating system for evaluating learning outcomes (RSO)

When the course work is completed, the following types of control are provided: current, calendar and semester.

***Current control** is carried out as a result of checking coursework tasks performed according to the schedule.*

***Calendar control** is carried out twice per semester. The student receives a positive grade from the calendar control, provided that the course work schedule is followed.*

***Semester control** is carried out in the form of coursework defense.*

***The condition of admission to the semester control is:** submission of the completed course work five days before the appointed date of the defense and a rating of the starting component of at least 30 points.*

Rating rating system

Each student's coursework rating consists of points obtained for 2 components:

1) *the starting component is assigned for the content and completeness of the presentation of research materials, the quality of the design of the explanatory note and compliance with the coursework performance schedule during the semester;*
2) *the coursework defense component is assigned for answers to the teacher's questions, the degree of mastery of scientific and technical terminology, the ability to explain the used research methods and their results.*

   The size of each of the above-listed components of the rating assessment is equal to 50 points.

Evaluation criteria

1) The quality of the explanatory note, graphic material and adherence to the work schedule during the semester.

The maximum number of points for the content, design and compliance with the coursework schedule is 24+10+16=50 points.

1.1. Awarding of points for the content of the work (maximum 24 points):

- *all items are completed in full, without errors; all actions are theoretically justified; results obtained through programming and mathematical modeling are accompanied by program texts or their fragments and Simulink - models with their parameters; in the conclusions to the work, the obtained results and methods of obtaining them are clearly formulated, a comparison of the results obtained by exact and approximate methods is made; qualified use of scientific and technical terminology; presentation style is logical and consistent. 22-24*
- *all items are completed in full but with minor errors; some actions are theoretically not convincing enough; results, for some results obtained by programming and mathematical modeling, program texts or their fragments and/or Simulink models are missing; the conclusions are formulated vaguely and/or incompletely; there are cases of unqualified use of scientific and technical terminology. 18-21*
- *some items are completed incorrectly; some actions are not theoretically justified; for some results obtained by programming and mathematical modeling, program texts or their fragments and/or Simulink models are missing; the conclusions do not correspond to the content of the work; the student has a poor command of scientific and technical terminology. 15-17*
- *more than half of the items are completed incorrectly and are not theoretically justified; for most of the results obtained by programming and mathematical modeling, program texts or their fragments and/or Simulink models are missing; there are no conclusions; the student hardly knows scientific and technical terminology. 0*

1.2. Awarding of points for registration of work (maximum 10 points):

- *the work is designed in accordance with the requirements; high quality design of graphic information and formulas 9-10*
- *minor errors in the design of the text part, graphs, formulas 7-8*
- *significant errors in design 6-7*
- *most registration requirements are not met 0*

1.3. Awarding of points for compliance with the work schedule (maximum 2 points for independent work points from 1st to 8th, total maximum 16 points for 8 points):

- *section of the work was completed in full and on time 2*
- *the section of the work was completed in full, but late with a delay of no more than two weeks 1.6-1.9*
- *the section is not completely completed without delay, or completely with a delay of more than two weeks 1.2-1.5*
- *section not completed at all or completed more than 4 weeks late 0*

2) Protection of term paper.

The defense of the term paper consists of answering questions based on an explanatory note. The maximum number of points for protection is 50.

The calculation of points for the defense of the course work is carried out as follows:

- excellent mastery of the material, correct answers to all questions 47-50

- good mastery of the material, answers to most questions 35-46

- satisfactory mastery of the material, answer to half of questions 30-36

- insufficient mastery of the material, incorrect answers or no answers to most of the questions 0

Calculation of the rating scale (R).

The maximum number of points for completing and defending the coursework is R=50+50=100 points.

In order for a student to receive appropriate grades in the ECTS system and in the traditional system, his rating grade R is translated according to the table:

R rating (sum of points)	*Final assessment*
95...100	*Perfectly*
85...94	*Very good*
75...84	*Good*
65...74	*Satisfactorily*
60...64	*Enough*
Less than 60	*Unsatisfactorily*
Failure to fulfill the conditions of admission to protection	*Not allowed*

Working program of the academic discipline (syllabus)

compiled by the professor of the department of automation of electromechanical systems and electric drives,

Dr. sc. Tolochko O.I._____

Approved by the Department of Automation of Electromechanical Systems and Electric Drives of the FEA

(protocol No. 15 of June 13, 2024)

Agreed by the Methodical Commission of the faculty (protocol No. 10 of June 20, 2024)