National technical university of Ukraine «IGOR SIKORSKY KYIV POLYTECHNIC INSTITUTE»

DEPARTMENT OF SPACE ENGINEERING

THEORY OF AUTOMATIC CONTROL COURSE WORK

Syllabus

General information	
Level of higher education	***The first (Bachelor)***
Field of knowledge	*13 Mechanical engineering*
Specialty	*134 Aerospace and rocket-space technology*
Educational program	*Aerospace and rocket systems engineering*
Discipline status	*Normative*
Form of education	*full-time (daytime)*
Year of study, semester	*2 course, spring semester*
Scope of discipline	*1 credit / 30 hours*
Form of final control	*Test / Course work*
Schedule	*In accordance to http://rozklad.kpi.ua*
Language of teaching	*English*
Teacher information	Lecturer: *candidate of technical sciences, Associate professor, Pysarets Anna, anna.v@ukr.net*
Course placement	Google Classroom

Academic discipline program

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

The purpose of the discipline *is training of highly qualified specialists in the theory of automatic control.*

Discipline subject *are fundamental concepts, definitions and principles of automatic control theory, control schemes and models, methods for analyzing automatic control systems in the time and frequency domains, which contributes to the accumulation of knowledge about the laws and properties of control processes for technical objects, regardless of their physical nature.*

Competencies *that the student will receive when studying the discipline are*

– *Ability to work in team (GC 5);*
– *Ability to work autonomously (GC 11);*
– *Ability to organize and use collaborative discussions of methods for solving unusual design problems (GC 12);*
– *Ability to interpersonal relation (GC 13);*
– *Ability to calculate the strength of components of aircraft and rocket and space technology (PC 4);*
– *Skills to use information and communicative technologies and specialized software in studying and professional activity (PC 7);*
– *Skills to use integral technologies of computer design and modeling of aircraft and rocket and space systems and elements (PC 14).*

Program results of learning *are*

- *Understand and reason the sequence in design, production, testing and/or certification of aircraft and rocket and space objects and elements at all stages of their life cycle (PRL 6);*
- *Understand the structure and principles of operation of onboard and navigation equipment of aircraft and rocket and space technology (PRL 7);*
- *Calculate the power plants of rockets and space vehicles: pulse engines, gas and gas turbine engines, flywheel engines, liquid and solid fuel rocket engines, solar batteries, generators, servo motors (PRL 12);*
- *Apply modern methods of modeling, design and manufacturing of aircraft and rocket and space elements and systems (PRL 18);*
- *Explain the influence of structural parameters of rocket and space vehicles on their performance. Know methods of stability and controllability of aircraft and rocket and space technology (PRL 22);*
- *Explain solutions and give arguments in their favor in reasonable and clear form (PRL 24);*
- *Skills for self-directed study and autonomous work for increasing professional qualification and solving the problems in new and unknown environment (PRL 25).*

2. Prerequisites and postrequisites of the discipline (position in the structural and logical scheme of training in the corresponding educational program)

The discipline is taught on the basis of the application of theoretical knowledge and practical skills that were obtained by students earlier in the study of a number of fundamental disciplines ("Higher Mathematics", "Physics", "Electrical Engineering" and others).
The knowledge and skills gained in the study of this discipline are used to study the disciplines of vocational learning.

3. The content of the discipline

Section 1. Basic concepts and definitions in the control theory.
Topic. Basic concepts and definitions in the control theory.

Section 2. Characteristics of dynamic elements.
Topic 1. Time responses.
Topic 2. Frequency responses.
Topic 3. Typical dynamic elements and their characteristics.

Section 3. Mathematical description of control systems.
Topic 1. Construction of initial differential equations of automatic control systems.
Topic 2. Transfer functions of automatic control systems.
Topic 3. Application of block diagrams. Multi-loop control systems.

Section 4. Automatic control systems stability.
Topic 1. Algebraic stability criteria.
Topic 2. Frequency stability criteria.

Section 5. Quality and accuracy of control systems.
Topic 1. Quality of control systems.
Topic 2. Root method. Frequency quality criteria.
Topic 3. Accuracy of control systems in typical modes.
Topic 4. Methods for improving the control systems accuracy.

Section 6. Improving the quality of the regulatory process.
Topic 1. Correcting devices. Methods for increasing the stability margin.

Section 7. Methods of control systems synthesis.
Topic 1. Methods of control systems synthesis.

4. Learning Materials and Resources

Basic literature

1. William Bolton, Instrumentation and control systems. Third edition. Elsevier, Newnes.
2. Norman S. Nise, Control systems engineering. California State Polytechnic University, Pomona. – Seventh edition.

Additional literature

1. *Dorf Richard C., Bishop Robert H., Modern control systems. 12 th ed. Prentice Hall, 1082 p.*
2. *Golnaraghi F., Kuo Benjamin C. Automatic Control Systems. 9th edition. John Wiley & Sons. Inc.*
3.

Educational content

5. Methodology for studying the discipline (educational component)

To master the discipline, it is planned to study the following questions:

1. Typical dynamic links. Link transfer function. Features of typical dynamic links.

2. Block-diagrams. Components of block diagrams. Typical element connections. Multi-loop control systems. Block diagram transforms.

3. Transfer functions of control systems.

4. Dynamics equations of control systems.

5. Frequency transfer function and frequency responses of control systems elements.

6. Control systems stability. Characteristic equation of control system. Roots of characteristic equation. Stability boundaries.

7. Hurwitz stability criterion.

8. Frequency stability criteria. Mikhailov stability criterion. Nyquist stability criterion.

9. System gain boundary value. Stability margins.

10. Stability regions.

11. Time responses of dynamic elements.

12. Quality characteristics of transient process.

13. Root quality indicators.

14. Accuracy of control systems in typical modes.

6. Student's independent work

Students are allocated 30 hours for independent work. 6 hours of this time are for preparing for the test.

Course work is divided into structural elements (separate assignments). Individual tasks are completed in accordance with the schedule.

Course work schedule

Topic list	*Due date (week of semester)*	*Independent work, hours*
Getting a task for a course work	*6*	
Transfer functions of the system according to the block	*7*	*2*

diagram. Control system differential equation.		
Frequency responses for open loop control system.	*8*	*2*
Study of the control system stability according to the location of the characteristic equation roots. *The Hurwitz criterion.*	*9*	*1*
Frequency stability criteria.	*10*	*2*
Calculation of the system gain boundary value. *Stability regions in the one parameter plane.*	*11*	*2*
Time responses for a closed loop system.	*12*	*2*
The performance measures. *Root methods for evaluating the quality of the transient process.*	*13*	*2*
The system steady-state error.	*14*	*2*
Preparing of the explanatory note.	*15*	*7*
Preparing for the course work defense.	*16*	*6*
The course work defense.	*17*	*2*
Total		***30***

Politics and control

7. Policy of academic discipline (educational component)

- *provision is made for consultations on issues arising in the implementation of the course work tasks;*
- *one week before the deadline for defending the work, it's necessary submit the completed work to be checked for compliance with the task and design requirements.*

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

A student's rating by discipline consists of the points had been receiving for completing

1) performance of work and its result (starting component);
2) defense of course work.

The size of the starting component (r_1) is 40 points; the course work defense component (r_2) is 60 points.

Scoring Criteria

Starting component (r_1):

- *justification of decisions made 10 – 6 points;*
- *correct application of analysis and calculation methods 10 – 6 points;*
- *quality of design, compliance with the requirements of regulatory documents 7 – 4 points;*
- *quality of graphic material and compliance with standards 7 – 4 points;*
- *timely implementation of the work schedule 6 – 3 points;*

Course work defense component (r_2)

- *mastery degree of the material 15 – 9 points;*
- *analysis completeness of possible options 15 – 9 points;*

- *validity degree of decisions made 15 – 9 points;*
- *ability to defend one's point of view 15 – 9 points.*

Semester control is test.
Conditions for admission to semester control are completed course work, a semester rating of more than 25 points.

The sum of starting marks and marks for the defense is converted into test grade in accordance with the table.

Correspondence table of rating points to assessments on the university scale:

Number of points	*Grade*
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactory
The conditions for obtaining a grade are not met	Not allowed

The working program of the academic discipline (syllabus):

Composed by associate professor, candidate of technical sciences, Anna Pysarets

Accepted by department of space engineering (protocol № 15 from 07.06.2023).

Agreed by the Methodological Commission of ER IAT (*protocol* № 6 from 22.06.2023).