Ministry of Education and Science of Ukraine
National Aerospace University
"Kharkiv Aviation Institute"

Department of Aircraft Control Systems (Dep. 301)

APPROVED:
Guarantor of Educational Program
_____ A. S. Kulik
«27» 08 2021

WORK PROGRAM OF THE COMPULSORY DISCIPLINE

Control System Designing
(name of the discipline)

Field of Study: 17 "Electronics and Telecommunication"

Program Subject Area: 173 "Avionics"

Educational Program: Systems of Autonomous Navigation and Adaptive Control of Aircrafts
(code number and the name of specialization)

Level of Qualification: 1st (bachelor degree)

Kharkiv 2021

Work program of compulsory discipline "Control System designing" is for English-speaking students of training direction 173 "Avionics".

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Developer:
I.V. Bychkova, senior lecturer of dep. 301 _____ (sign)

The work program has been examined at the meeting of dep. 301 "Aircraft Control Systems".

Record of proceeding: No. "1" from «_27_» ___08___ 2021

Head of the department
PhD (Engineering), Candidate of Science _____ (sign) K. Yu. Dergachov

1. Course description

<table>
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<tr><td colspan="2">Full-time study</td></tr>
<tr><td colspan="2">ECTS credits – 9</td><td colspan="2" rowspan="3">Knowledge Areas
0511 "Aviation and rocket and space technology",</td><td colspan="2">Professional training area</td></tr>
<tr><td colspan="2">Modules – 4</td><td colspan="2" rowspan="2">Calendar year</td></tr>
<tr><td colspan="2">Semantic modules – 4</td></tr>
<tr><td colspan="2" rowspan="2">Research into the topic
_____
(topic name)</td><td colspan="2" rowspan="3">Training Direction:
6.051103 - Avionics</td><td colspan="2">2020-2021</td></tr>
<tr><td colspan="2">Semester</td></tr>
<tr><td>7</td><td>8</td></tr>
<tr><td colspan="2">Total hours – 324</td><td colspan="2" rowspan="4">Specialization:</td><td colspan="2">Lectures [1)]</td></tr>
<tr><td colspan="2">Academic hours per day for full-time study</td><td>30</td><td>28</td></tr>
<tr><td colspan="2">Semester 7</td><td colspan="2">Tutorial classes [1)]</td></tr>
<tr><td>classroom – 4</td><td>self-study – 5.6</td><td>15</td><td>28</td></tr>
<tr><td colspan="2">Semester 8</td><td colspan="2" rowspan="3"></td><td colspan="2">Lab classes [1)]</td></tr>
<tr><td>classroom – 6</td><td>self-study – 6.9</td><td>15</td><td>28</td></tr>
<tr><td colspan="2" rowspan="4"></td><td colspan="2" rowspan="3">Education level:
1st (bachelor degree)</td><td colspan="2">Self-study (unaided) work</td></tr>
<tr><td>84</td><td>96</td></tr>
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<tr><td colspan="2">Assessment form</td></tr>
<tr><td colspan="2"></td><td colspan="2">Exam</td><td>Exam, differen-tial offset</td></tr>
</table>

1) depending on actual timetable, classroom studies can decrease or enlarge by one hour in a week

Note: ratio of classroom working and unaided (independent) work makes:
– 144/180 (under full-time education).

2. Purpose and objectives of academic discipline

Learning Aims – creation of knowledge and skills necessary for the design of automatic control systems (ACS) technical objects..

Learning Objectives – to study the information organizational, methodological, technical, linguistic and algorithmic design ACS database.

Learning Outcomes – on successful of the subject, students

should know

- types of objects and ACS, their main characteristics;
- ACS life cycle;
- the development, coordination and approval of the terms of reference (TOR) for the various stages of design ACS;
- tasks, methods, tools and results of the preliminary sketch and technical design of the ACS;
- types, stages and tasks of the research;
- method of semi natural modeling ACS;
- methods of design and choice of rational structure ACS options;

should be able to

- develop TOR for preliminary and schematic design of ACS;
- develop the technical proposal for the design of ACS;
- choose ACS configuration, perform power, signal information and coordination of the functional elements of the ACS;
- to carry out the theoretical part of a draft ACS;
- to carry out a pilot of a draft ACS;
- perform computer simulations ACS;

have a general notion

- the structure of the project company;
- the design processes of production, operation, upgrading, decommissioning and disposal of ACS elements.

3. Content of the course

Module 1

Semantic Modulus 1. Objectives, methods, tools and results of the preliminary design of ACS

Topic 1. Introduction to the discipline.
Subject and problems of discipline. The basic concepts. Task and aim of control system designing.

Topic 2. Classification and basic characteristics of objects and ACS.
Classification of the ACS. ACS properties. Dynamic and frequency quality parameters of system.
Topic 3. Life cycle stages of ACS

The idea of ACS. ACS Design. Construction of ACS. ACS Production. Operating of ACS. The development of ACS. Decommissioning of ACS

Topic 4. Development, coordination and approval of technical specifications

The process of development, coordination and approval of technical specifications. The process to the requirements specification. Factors that affect the ACS.

Topic 5. Research and rationale for developing ACS.

Scientific research (SR). Preliminary design. Research classification. Objectives and designer task in different stage of research work.

Topic 6. Preliminary and engineering design of ACS.

The tasks of preliminary design. Stages of conceptual (engineering) design. Source documents for the TP.

Topic 7. The tests in the development of control systems.

Objectives Test. Types of tests. Technical means of tests. Test program. The test procedure. Handling of test results.

Topic 8. Organizational basis of the design process.

Stages of design process. Main concepts for designing control system for complex objects. Basic control law realization. Examples of complex control system and its implementation.

Topic 9. Modeling of objects and control systems.

Problems of modeling. Kinds of models. Preparation of the problem to the seminatural simulation for teaching and research bench.

Topic 10. Semi-natural simulation of digital systems of automatic control.

Algorithm of semi-natural modeling of DACS. Methods of semi-natural modeling of DACS at the educational and research stand the universal bench. Semi-natural modeling of system of automatic stabilization of pitch angle of the SU-27 aircraft.

Module 2

Semantic Modulus 2. Objectives, methods, tools and results of conceptual and technical design of ACS.

Topic 11. Choice and matching of the elements of ACS

Characteristics (static, dynamic, time, frequency) of the elements of ACS. Selecting of the elements of ACS. Matching of the elements of ACS.

Topic 12. Choice of structure ACS.

Statement of the problem of synthesis of regulators. The main stages of the design of ACS. Selection of options block diagram of ACS.

Topic 13. Multicriteria designing of ACS.

The generation of a plurality of structures of ACS. Algorithms for designing the set of possible control devices. Control devices with enough of units correction. Selection of Pareto-optimal structures ACS.

Topic 14. Evaluation of the complexity of control systems.

Evaluation of the complexity of the control object. Evaluation of the complexity of the analog control devices. Evaluation of the complexity of digital control devices.

Topic 15. Creative and uncreative components of design processes.

The general scheme of design processes. The main procedure of design processes. Some methods of creative solutions of problems. The levels of inventions.

Module 3

Semantic Modulus 3. Designing control system for aerospace objects in application to bachelor project.

Topic 16. The formalize a title page, a design task and a review to final work of bachelor.
The order and example of formalize a title page to final work of bachelor. The order and example of formalize a design task to final work of bachelor. The order and example of formalize a review to final work of bachelor.

Topic 17. The order and example of formalize a title page to final work of bachelor.

The order and example of formalize requirement specification to final work of bachelor. The order and example of formalize list abstract to final work of bachelor.

Topic 18. The formalize contents, list of nomenclatures and abbreviations and introduction.
The order and example of formalize contents to final work of bachelor. The order and example of formalize list of nomenclatures and abbreviations to final work of bachelor. The order and example of formalize introduction to final work of bachelor.

Topic 19. The formalize statement of the problem to final work of bachelor.
Review of problem. Analyze current situation in modern technical level. Content of project.

Topic 20. The formalize analysis and synthesis of system
Mathematical model of control object. Structure of automatic control object. Nonlinear and linear mathematical model. Transfer functions.

Topic 21. Analysis of uncorrected system.
Choosing parameters for sensors, actuators of system. Computer modeling for uncorrected control system. Determination of main quality parameters.

Topic 22. Synthesis of control system.
Choose structure of devise of automatic control. Compare type and methods of system correction. Frequency correction methods.

Topic 23. Analysis of corrected system.
Static and dynamic calculation. Computer model for automatic control system. Quality parameters for final modeling.

Topic 24. Semi-natural simulation.
Creation model and system equation. Scaling. Working with modeling results.

Topic 25. The formalize design and technological part to final work of bachelor
The order and example of formalize design part to final work of bachelor. The order and example of formalize technological part to final work of bachelor.

Topic 26. The formalize conclusion and list of sources

The order and example of formalize a conclusion to final work of bachelor. The order and example of formalize a list of sources to final work of bachelor

Topic 27. The formalize poster
Structure and content of posters. Documentation requirement.

Topic 28. The formalize appendices
The order and example of formalize appendices to final work of bachelor

Topic 29. The general rules of making final work of bachelor
General requirements to final work of bachelor. Pagination text document. The numbering of sections, subsections, paragraphs, subparagraphs. The illustrations, charts, diagrams charts and scheme. Formulas and equations. Tables.

Module 4

Semantic Modulus 4. Course Project

Topic 30. Synthesis ofcontrol system for aerospace objects.

Completing the tasks of the course project (see the topic of practical classes).

5. Topics of seminar classes

№ a/o	Topic name	Hours
1	Not assigned	

6. Topics of tutorial classes

Module 1

№ a/o	Topic name	Hours
1	Choosing structure of control system and best element for its implementation	5
2	Assessment of design problems ACS	5
3	The study object management	5
4	Development of functional circuit ACS	5
5	The choice of initial control law	5
6	Research ACS	5
7	Correction ACS	13
Total hours		43

7. Topics of lab classes

Module 1

№ a/o	Topic name	Hours
1	Investigation stabilization system the pitch angle of transport aircraft.	4
2	Investigation stabilization system the pitch angle of jet aircraft with a damping circuit	6
3	Investigation System of stabilization of pitch angular velocity of jet aircraft.	6
4	Investigation flight speed stabilization system of the aircraft	6
5	Introduction to working bench	2
6	Studying of the quality parameters of the system	4
7	Investigating the servomechanism of universal study bench	4
8	Position Control of Servo Mechanism Using PID Controller	4
9	Semi natural simulation angular stabilization a system of aircraft SU-27.	7
Total hours		43

8. Self-study (unaided) work

№ a/o	Topic name	Hours
1	Development, coordination and approval of TOR	10
2	Research and study the need for and feasibility of developing ACS	10
3	Preliminary design and technical	10
4	Tests in the design of ACS	10
5	Modeling objects and systems management	15
6	Selection and coordination elements SAU	10
7	The choice of a rational configuration of ACS	10

8	Designing multi ACS	10
9	Assessment SAU	10
10	How to optimize ACS	10
11	TK Development course project	10
12	Assessment of design problems ACS	10
13	Learning Object Management	10
14	Development of functional circuit ACS	10
15	The choice of initial control law	10
16	Research ACS	10
17	Correction ACS	15
Total hours		180

9. Individual assignments

№ a/o	Topic name	Hours
1		

10. Learning methods

Lectures delivering, conducting lab classes, individual consultations (if necessary), independent work of students on materials issued by the department (teaching manuals),

11. Forms of control

Current control tests in form of lab report submission, defense of individual assignments corresponding to semantic modules and topics, final examination.

12. Assignment of grade points obtaining by a student (exam)

Semester 7

Class tests and unaided work			Summative test (examination) due to refusing the received current grade points and intent taking the exam if allowed
Semantic Modulus №1 (weight)	Semantic Modulus №2 (weight)	Grade points total	
T1 – T10	T11 – T15	100	100
50	50		

4. Course structure

Semantic modules and topics	Hours					
	full-time					part-time
	total	among them				
		lecture	tutor	lab	indep	
1	**2**	**3**	**4**	**5**	**6**	**7**
Module 1						
Semantic Modulus 1 – Objectives, methods, tools and results of the preliminary design of ACS						
Topic 1. Introduction to the discipline	3	2			1	
Topic 2. Classification and basic characteristics of objects and ACS	7	2	1		4	
Topic 3. Life cycle stages of ACS	6	2			4	
Topic 4. Development, coordination and approval of technical specifications	10	2	2		6	
Topic 5. Research and rationale for developing ACS	12	2	2		8	
Topic 6. Preliminary and engineering design of ACS.	10	2	2		6	
Topic 7. The tests in the development of control systems	9	2		2	5	
Topic 8. Organizational basis of the design process	7	2			5	
Topic 9. Modeling of objects and control systems	16	2		4	10	
Topic 10. Semi-natural simulation of digital systems of automatic control.	16	2	2	4	8	
Total for semantic modulus 1	96	20	9	10	57	
Module 1 total	96	20	9	10	57	
Module 2						
Semantic Modulus 2 – Objectives, methods, tools and results of conceptual and technical design of ACS.						
Topic 11. Choice and matching of the elements of ACS	8	2		3	3	
Topic 12. Choice of structure ACS	12	2	2	2	6	
Topic 13. Multicriteria designing of ACS	10	2	2		6	
Topic 14. Evaluation of the complexity of control systems	10	2	2		6	
Topic 15. Creative and uncreative components of design processes	8	2			6	
Total for semantic modulus 2	48	10	6	5	27	

Module 2 total	48	10	6	5	27	
Module 1-2 total(Semester 7)	144	30	15	15	84	
Module 3						
Semantic Modulus 3 – Designing control system for aerospace objects in application to bachelor project						
Topic 16. The formalize a title page, a design task and a review to final work of bachelor.	5	2			3	
Topic 17. The order and example of formalize a title page to final work of bachelor	5	2			3	
Topic 18. The formalize contents, list of nomenclatures and abbreviations and introduction	5	2			3	
Topic 19. The formalize statement of the problem to final work of bachelor	9	2		2	5	
Topic 20. The formalize analysis and synthesis of system	13	2		4	7	
Topic 21. Analysis of uncorrected system	11	2		4	5	
Topic 22. Synthesis of control system	15	2		6	7	
Topic 23. Analysis of corrected system	11	2		4	5	
Topic 24. Semi-natural simulation	17	2		8	7	
Topic 25. The formalize design and technological part to final work of bachelor	7	2			5	
Topic 26. The formalize conclusion and list of sources	7	2			5	
Topic 27. The formalize poster	7	2			5	
Topic 28. The formalize appendices	7	2			5	
Topic 29. The general rules of making final work of bachelor	7	2			5	
Total for semantic modulus 3	126	28		28	70	
Module 3 total	126	28		28	70	
Module 4 **Semantic Modulus 4** – Course project						
Topic 30. Synthesis ofcontrol system for aerospace objects.	54		28		26	
Total for semantic modulus 4	54				26	
Module 4 total	54	-	28	-	26	
Module 3-4 total(Semester 8)	180	28	28	28	96	
Course total	**324**	**58**	**43**	**43**	**180**	

Semester 8 (examination)

Class tests and unaided work			Summative test (examination) due to refusing the received current grade points and intent taking the exam if allowed
Semantic Modulus №1 (weight)		Grade points total	
T16 – T29		100	100
100			

Semester 7

Current tests and unaided work		Final score by Course Project
Semantic Modulus №4	Total	
T30	100	100
100 (25 points for each section of the course project in accordance with the topics of practical classes		

13. Recommended reading

Basic

1. Автоматизированное проектирование САУ /Я.Я. Алексанкин, Ф.Э. Бржозовский, В.А. Жбанов и др. Под. ред. В.В. Солодовников. – М. Машиностроение. 1990. – 332 с.

2. Дитрих Я. проектирование и конструирование: Системный подход. – М.: Мир. 1981. – 456 с.

3. Никулин Е.А. Основы теории автоматического управления. Частотные методы анализа и синтеза систем. – СПб.: БХВ – Петербург. 2004. – 640 с.

4. Основи цифрових систем /І.П. Барабаш, М.П. Благодатний, В.Я. Жихарев і ін. – Харків: Нац. аерокосмічний ун-т «ХАІ», 2002. – 672 с.

5. Тищенко Н.М. введение в проектирование систем управления. – М.: Энергоатомиздат, 1986. – 248 с.

6. Сольницев Р.И. Автоматизация проектирования систем автоматического управления. – М.: Высш. шк., 1991. – 335 с.

Complementary reading

1. Боднер В.А. Системы управления летательными аппаратами. – М.: Машиностроение. 1973. – 506 с.