

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

Department of Aircraft Control Systems (Dep. 301)

**APPROVED**

Leader of the Project Group

 A. S. Kulik

«\_\_\_\_» \_\_\_\_\_ 2020

**WORK PROGRAM OF THE COMPULSORY DISCIPLINE**

**Mathematical Basis of Digital Avionics Systems**

(code and 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)

**Form of study: full-time**

**Level of Qualification:** 1<sup>st</sup> (bachelor degree)

Kharkiv 2020

Study program of compulsory discipline – Mathematical Basis of Digital Avionics Systems» is for English-speaking students of training direction 173 – Avionics.

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The program has been examined at the meeting of dep. 301 “Aircraft Control Systems”.

Record of proceeding: No. “29” from «29» 08 2020

Head of the department  
Phd (Engineering), Candidate of Science

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K. Yu. Dergachov

### 1. Course description

Indices	Field of Study, Program Subject Area, Educational program, Level of Qualification	Course specification
		Full-time study
ECTS credits – 5	Field of Study: 17 “Electronics and Telecommunication:	Compulsory
Modules – 1		<b>Calendar year</b>
Substantial modules – 2		
Individual Assignment: –	Program Subject Area: 173 “Avionics”	2020/2021
		<b>Semester</b>
		4
Total hours – 72/150	Educational Program: Systems of Autonomous Navigation and Adaptive Control of Aircrafts	<b>Lectures</b>
		32
		<b>Tutorial classes</b>
Academic hours per week for full-time study: classroom – 4.5, self-preparation – 4.9	Level of Qualification: <u>1<sup>st</sup> (bachelor degree)</u>	8
		<b>Lab classes</b>
		32
		Self-study work
		78
		Assessment form
		Exam

**Note:** ratio of classroom working and unaided (independent) work makes: 72/78 (under full-time education).

## 2. Purpose and objectives of academic discipline

**Learning Aims** – to study methods that allow analytically to study mathematical models (correctness, completeness, complexity, stability of solutions, etc.), to study algorithms of machine solution of complex mathematical problems, basic laws and functions of logic algebra, rules of logical operators, mathematical description of digital elements and avionics systems.

**Learning Objectives** – study of mathematical theories (basic laws and functions of the logic algebra), methods which in phenomena, processes, bodies give an opportunity to investigate the most common properties, abstracting from those properties which are not essential, the study of algorithms for the formation of software solutions for problems in digital avionics systems.

According to the requirements of the educational-professional program, students should achieve the following **competencies**:

GC1. The capacity for abstract thinking, analysis and synthesis.

GC 5. The ability to learn and master the latest knowledge.

GC 6. The ability to search, process and analyze information from different sources

GC 8. The ability to make informed decisions.

GC 11. The ability to work autonomously.

PCS1. The ability to use basic knowledge of basic national, European and international regulations in the field of avionics in order to continuously improve their professional activities.

PCS2. The ability to use science and technology in the profession, to argue the choice of methods for specialized tasks of analysis and synthesis systems in avionics

PCS 3. The ability to implement and use hardware and software-algorithmic tools to increase the accuracy and reliability of control systems and other qualities of the aircraft.

PCS 9. The ability to introduce achievements of domestic and foreign science and engineering, to use innovative experience in avionics.

### **Program learning outcomes:**

PLO2. Use a basic knowledge of major national, European and international regulations in the field of avionics for the purpose of continuous improvement of their professions-term activity.

PLO3. Use science and technology in the professional activity, to argue the choice of methods for solving specialized tasks of analysis and synthesis of avionics

PLO4. Use modern technology automation design and construction information and control systems in the field of avionics, be able to create hardware and software



regarding increasing accuracy, reliability of control and other aircraft qualities  
 PLO12. Use modern information and communication technology in avionics

### **Interdisciplinary Relations:**

Prerequisites for studying this discipline:

Higher mathematics: differential and integral calculus; exploring functions and plotting them. Informatics: basics of work on the computer.

The course supports the following courses:

Microcontrollers in control systems. Automatic Control Theory. Digital Control System

## **3. Content of the course**

### **Module 1**

**Substantial module 1.** Discrete mathematics basics

**Topic 1.** Subject and object of discrete mathematics

Subject start from general questions of using mathematics in engineering work. The mathematical apparatus of engineer is defined as the interconnected set of language, models and methods focused on the solution engineering tasks.

**Topic 2.** Sets and their basic properties

The concept of a set as one of basic concepts of mathematics. It has no precise definition, and generally explained by the following examples.

**Topic 3.** Relations and their properties

Cartesian product. Display of sets. The relations on sets. Types and properties.

**Substantial module 2.** Logical algebra, Boolean logic.

**Topic 4.** Basic concepts and definitions of Boolean logic

Basic concepts and definitions of Boolean logic. The logical algebra - a mathematical apparatus by which recording is calculated, simplify and convert the logical statements.

**Topic 5.** Combinatory elements

Combinatorial tasks related to the calculation the number of samples of size  $r$  of  $n$  elements, where the sample is subject to certain conditions, the selection is made on some principle. Counting the number of samples, it is based on two rules of set theory.

**Topic 6.** Number theory

The history of the theory of numbers. Euclid's algorithm. Simple and composite numbers. Eratosthenes sieve.

**Topic 7.** Finite state machine

Finite state machine. Deterministic finite state machine. Nondeterministic finite state machine. Regular expression. Turing machine.

#### 4. Course structure

Semantic modules and topics	Auditorium hours				
	full-time part-time				
	total	among them			
lecture		tutor	lab	indep	
<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>
<b>Module 1</b>					
<b>Substantial Module 1 – Discrete mathematics. Sets. Logic algebra.</b>					
<b>Topic 1.</b> Input lecture. Subject and object of discrete mathematics	13	4	-	-	9
<b>Topic 2.</b> Sets and their basic properties	28	6	2	8	12
<b>Topic 3.</b> Relations and their properties	28	6	2	8	12
<b>Control module 1</b>	5	-	-	-	5
<b>Total for Substantial Module 1</b>	74	16	4	16	38
<b>Substantial Module 2 – Logical algebra, Boolean logic.</b>					
<b>Topic 4.</b> Basic concepts and definitions of Boolean logic	18	4	1	4	9
<b>Topic 5.</b> Combinatory elements	17	4	1	4	8
<b>Topic 6.</b> Number theory	17	4	1	4	8
<b>Topic 7.</b> Finite state machine	19	4	1	4	10
<b>Control module 2</b>	5	-	-	-	5
<b>Total for Substantial Module 2</b>	76	16	4	16	40
<b>Module 1 Total</b>	<b>150</b>	<b>32</b>	<b>8</b>	<b>32</b>	<b>78</b>

#### 5. Topics of seminar classes

No. a/o	Topic name	Hours
1	Not appointed	

#### 6. Topics of tutorial classes

##### Module 1

No. a/o	Topic name	Hours
1	Theory of sets. Basic concepts.	1
2	Theory of sets. The relationship between sets. Venn Diagram.	1
3	Functions and relations. Algebra statements.	1

4	Combinatorics.	2
5	Logical algebra, Boolean logic.	1
6	Graph theory.	1
7	Machine analysis. Turing machine.	1
	<b>Total</b>	<b>8</b>

### 7. Topics of lab classes

#### Module 1

No. a/o	Topic name	Hours
1	Studying methods of algebra of sets. Program implementation of actions on sets	8
2	Solving problems of combinatorics using Matlab	8
3	Development of a program for finding routes based on the theory of graphs	4
4	Research work numerical mathematical functions and actions in the program Matlab	6
5	Interpolation of functions	6
	<b>Total</b>	<b>32</b>

### 8. Self-study (unaided) work

No. a/o	Topic name	Hours
1	Theories of sets. Relations between sets. Venn Diagrams	10
2	Theories of sets. Operations on sets. Power of the set	10
3	Functions and relations	10
4	Combinatorics	10
5	Graph theory	10
6	Analysis of algorithms. Turing's machines.	14
7	Finite state machine	14
	<b>Total</b>	<b>78</b>

### 9. Individual assignments

No. a/o	Topic name	Hours
1	Not appointed	

### 10. Teaching methods

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



## 11. Modes of Assessment

The planned modes of assessment include lab report submission, defense of individual assignments in correspondence with substantial modules and topics, final examination.

## 12. Assessment criteria and points distribution that students receive

### 12.1. Points distribution that students receive

#### 4 semester

Components of educational work	Marks per lesson (task)	Number of lessons (tasks)	Total marks
<b>Substantial Module 1</b>			
Lectures work	0...1	8	0...8
Execution and protection of laboratory works	0...3	8	0...24
Execution and protection of practical works	0...3	8	0...24
Module 1	0...6	1	0...6
<b>Substantial Module 2</b>			
Lectures work	0...1	8	0...8
Execution and protection of laboratory works	0...3	8	0...24
Execution and protection of practical works	-	-	-
Module 2	0...6	1	0...6
<b>Total for the semester</b>			<b>0...100</b>

Semester control (exam/pass) is carried out in case of student refusal from the marks of the current testing and in the presence of admission to the exam/pass. During the semester exam/pass the student has the opportunity to receive a maximum of 100 marks.

The ticket for the exam/pass consists of one theoretical question (30 points), one practical question (30 points) and one laboratory task that must be completed on a computer (40 points).

### 12.2. Qualitative evaluation criteria

Knowledge required for good mark: knowledge in sets, Boolean function, Venn diagram and sufficient skills in the MATLAB environment, which provides great opportunities for digital systems.

Required skills for good mark: to be able to use: methods for set analyzing and calculating the Boolean functions. To be able to work in the MATLAB.



### 12.3. Evaluating criteria of the student work during the semester

#### 1. Excellent (90 ÷ 100 points):

1.1 Student knows the basic concepts and principles pertaining to the discipline "Electrical Engineering". Student has defended all practical, laboratory and individual tasks, completed all modular tasks with an "excellent" mark, student has excellent practical skills in circuit design. Freely uses the educational and scientific literature on the discipline subject. Student can logically and clearly form his answer, solve practical and laboratory tasks. An excellent performance, clearly outstanding. Student demonstrates excellent judgement and a very high degree of independent thinking.

1.2 A reduction in the number of the mark points is possible with inaccurate wording in the answers to the additional questions posed to student.

#### 2. Good (75 ÷ 89 points):

2.1 Student has sufficient knowledge of the theoretical part of the discipline. Defended all practical, laboratory and individual tasks, completed all modular tasks with a "good" mark, has practical skills in circuit design. Correctly solves practical tasks, student's answers are not clear. A good performance in most areas. Student demonstrates a reasonable degree of judgement and independent thinking in the most important areas.

2.2 A reduction in the number of the mark points is possible if the theoretical or practical questions are not fully answered.

#### 3. Satisfactory (60 ÷ 74 points):

3.1 Student has weak theoretical knowledge, has a minimum of knowledge and skills, makes mistakes in solving practical problems. Has defended all practical, laboratory and individual tasks, completed all modular tasks, has unsure practical skills in circuit design. A satisfactory performance, but with significant shortcomings. Student demonstrates a limited degree of judgement and independent thinking.

3.2 A reduction in the number of the mark points is possible due to inaccurate and incomplete answers to theoretical and practical questions.

### Grading scale: national

Total marks	National validation grade	
	Exam	Pass
90 – 100	excellent	pass
83 – 89	good	
75 – 82		
68 – 74	satisfactory	
60 – 67		
0 – 59	unsatisfactory	no pass

### 13. Methodical support

1. Summary of lectures on discipline "Mathematical Basis for Digital Systems".
2. Instructions and assignment for laboratory course.

3. Educational Methodical Complex of Discipline in electronically hosted on the server of the dep. 301.

<https://drive.google.com/drive/u/0/folders/1AZxeeG8SQmo2Oara3PgzO-QCjPvpTCQX>

#### **14. Recommended reading**

##### **Basic sources**

1. R. Johnsonbaugh Discrete mathematics Prentice Hill, 2008.
2. Brian Hopkins, Resources for the teaching of discrete mathematics, American Mathematical Association, 2008
3. Cyclic evidence of completion of the program in the division of logic, Brotherton J, R Bornat, C Calcagno, ACM SIGPLAN message, therefore, 43, issue 1 (January 2008)
4. Kenneth H. Rosen, Manual of Discrete and Combined Mathematics CRC Press. ISBN 0-8493-0149-1.

##### **Complementary reading**

1. John Dwyer & Suzy Jagger, Discrete Mathematics for Business & Computing, 1st Edition. 2010 ISBN 978-1907934001.
2. Andrew Simpson, Discrete Mathematics in McGraw Hill Examples. ISBN 0-07-709840-4
3. Ralph P. Grimaldi, Discrete and Combined Mathematics: Applied Introduction 5th form. Addison wesley ISBN 0-20-172634-3
4. Norman L. Biggs, Discrete Mathematics, 2 nd type. Oxford University Press. ISBN 0-19-850717-8

#### **15. Information resources**

Department's site: [k301info](http://k301info)