Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

Кафедра
Систем керування
літальними апаратами

Intelligent control systems

Work program of the discipline (Syllabus)

Details of the discipline	
Level of higher education	***Third (educational and scientific)***
Field of knowledge	*Electronics and telecommunications*
Specialty	*173 Avionics*
Educational program	*Control systems of flight vehicles and complexes engineering*
Discipline status	*Normative*
Form of study	*full-time (day) / full-time (evening) / part-time*
Year of preparation, semester	*2nd year, autumn semester*
The scope of discipline	*6 credits (180 hours)*
Semester control / control measures	*examination*
Timetable	*Rozklad.kpi.ua*
Language of teaching	*English*
Information about course leader / teachers	Lecturer: Candidate of Technical Sciences, Associate Professor Vitalii Vitalievich Burnashev, tel. +044-2048222, e-mail: vvvburnashev@gmail.com Practical: Candidate of Technical Sciences, Associate Professor Vitalii Vitalievich Burnashev, tel. +044-2048222, e-mail: vvvburnashev@gmail.com
Course placement	Sikorsky platform, https://www.sikorsky-distance.org/

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

The discipline "Intelligent Control Systems" is a compulsory subject.

The purpose and objectives of the discipline

The purpose of the discipline is the formation of graduate students the following abilities in accordance with the educational and scientific program:

The purpose of the credit module is to form students' abilities:

- to abstract thinking, analysis and synthesis (ZK01);
- to search, processing and analysis of information from various sources (ZK02);
- ability to use modern information technologies, specialized software in scientific and educational activities (FC 02);
- to develop models, methods and control algorithms (FC 04).
- ability to develop models, methods and technologies for diagnosing control systems (FC 05).

The main tasks of the discipline.

According to the requirements of the educational and scientific program, postgraduate students after mastering the discipline must demonstrate the following knowledge and skills:

- advanced conceptual and methodological knowledge of control systems, sufficient for scientific and applied research at the level of the latest world achievements, obtaining new knowledge (ZN 1);

- to develop and research conceptual, mathematical and computer models of processes and systems, to use them effectively to gain new knowledge and / or create innovative products in the field of aircraft control systems (UM 1);

- to implement on the basis of the conducted researches software and hardware means and packages of applied programs for designing of control systems of aviation and rocket and space equipment (UM 3);

- to develop and analyze new algorithms for the operation of aerobatic navigation systems of aircraft in conditions of uncertainty and incompleteness of a priori information (UM 4).

- to analyze existing and synthesize new methods and models for diagnosing aircraft control systems (UM 5).

Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

To master the discipline "Intelligent Control Systems" requires knowledge and skills that students will receive during the study of disciplines of the second (master's) level of training in the specialty 173 "Aircraft and complex control systems": Pattern Recognition Systems (PO3), Scientific work on the topic of master's dissertation (PO5).

The knowledge and skills that graduate students acquire in the process of studying the discipline "Intelligent Control Systems" can be used to form a dissertation of a doctor of philosophy in the specialty 173 Aivionics.

The content of the discipline

Table 1

Names of sections and topics	Number of hours				
	Total	including			
		Lectures	Practical		IWS
Topic 1. Basic concepts of intellectual control	38	2			34
Topic 2. Fundamentals of fuzzy logic	24	2	2		20
Topic 3. Dynamic object control systems based on fuzzy logic	12		2		10
Topic 4. Artificial neural networks	26				26
Topic 5. Design of regulators based on artificial neural networks	38	2			36
Calculation work	4	2			2
Home test	10				10
Examination	30				30
Total Hours	180	8	4		168

Training materials and resources

Basic literature:

1. Апостолюк В.О., Апостолюк О.С. Інтелектуальні системи керування – К.: НТУУ «КПІ», 2008. – 88 с.

2. *Пупков К.А., Егупов Н.Д.* Методы классической и современной теории автоматического управления. Том 5: Современная теория управления. – М.: МГТУ им. Н. Э. Баумана, 2004. – 766 с.

2. Пупков К. А., Егупов Н.Д. Методы классической и современной теории автоматического управления. Теория оптимизации автоматического управления. – М.: Издательство МГТУ им. Н. Э. Баумана, 2004. – Т. 4.– 744 с.

3. *Поляк Б.Т.* Робастная устойчивость и управление. – М.: Наука, 2002. – 303 с.

4. *Макаров И.М., Лохин В.М., Манько С.В., Романов М.П., Евстигнеев Д.В.* Интеллектуальные системы управления беспилотных летательных аппаратов на основе комплексного применения технологии нечеткой логики и ассоциативной памяти // Авиакосмическое приборостроение. – 2002 г. –№2. – С.29–42.

5. Sigurd Skogestad, Ian Postlethwaite. Multivariable Feedback Control: Analysis and Design. 2nd Edition, New York: Wiley, 2005

Additional literature:

6. *Макаров И.М., Лохин В.М., Манько С.В.*. *И*нтеллектуальная система управления автоматической посадкой беспилотного летательного аппарата на основе комплексного применения технологии нечеткой логики // Авиакосмическое приборостроение. – 2004 г. – №10. – С.30–40.

7. *Пашковский И.М.* Динамика и управляемость самолета. – М.: Машиностроение . 1987. 247 – с.

8. *Н.В. Ким, Н.В. Степанова*. Определение углов крена и тангажа беспилотного летательного аппарата на основе обработки и анализа последовательности изображений подстилающей поверхности //Авиакосмическое приборостроение. – 2006 г. – № 8. – с.18-23.

9. Seung-Hwan Kim, C. Song. A robust adaptive nonlinear control approach to missile autopilot design // Control Engineering Practice, 2004. – 12(2), pp 149-154.

10. López J., Dormido R., Dormido S. and Gómez J. P. A Robust $H\infty$ Controller for an UAV Flight Control System // The Scientific World Journal, 2015, 11 p.

Educational content

Methods of mastering the discipline (educational component)

Lectures

Table 2

№	The title of the lecture topic
1	Lecture 1. **Introduction. Basic concepts of intelligent control** References : [1] c.15-28, [11] c.22-29. Tasks on IWS. The concept of artificial intelligence (AI). Areas of research in the field of AI. The role of models and methods in AI. Soft calculations. References : [1] c.549-580
2	**Lecture 2. History of fuzzy logic. Fuzzy logic as a language for describing systems. Fuzzy sets. The principle of fuzzy rules. Key concepts of fuzzy logic.** References : [1] c.29-33, [10] c.80-84. Tasks on IWS. Perceptron training algorithm, convergence of training algorithm

	and selection of quantitative characteristics of weights.
3	**Lecture 3. Operations on fuzzy sets. Fuzzy numbers. Arithmetic operations on fuzzy numbers. Fuzzy relationship. The principle of generalization. Fuzzy implications. Rules of logical inference. The concept of fasification and dephasification.** References : [1] c.55-60, [10] c.85-91.
4	**Lecture 4. Procedure for the synthesis of fuzzy regulators. Methods of dephasification. Maximum method.** References : [1] c.51-56, [10] c.95-99. Tasks on IWS. The method of the average of the maxima.

Practical classes

The purpose of practical classes is to consolidate in practice the theoretical knowledge gained at Lecture. The following topics are provided.

1. Synthesis of fuzzy regulator based on knowledge obtained from an expert
2. Modular control work

Individual tasks

The individual task from the credit module "Intelligent control systems" is performed in the form of home test (HT).

The main objectives of the HT are to gain in-depth knowledge and practical experience in solving problems of fuzzy logic and synthesis of intelligent regulators

Policy and control

Independent work of a student

Independent work of a student / graduate student (IWS) is to prepare for classroom activities, acquaintance with thematic literature, performing independent work. The volume and topics of independent work of graduate students are given in Table. 1, 2.

Course policy (educational component)

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Grading policy (missed classes, passing of passes): each grade is set in accordance with the criteria developed by the teacher and announced in advance to graduate students, and is motivated individually at the request of the graduate student; in case the graduate student does not complete all the planned classes, he is not allowed to take the exam; missed classes must be completed. The form and time of work are coordinated by the graduate student and the teacher.

Policy of academic behavior and integrity (plagiarism, behavior in the audience): conflict situations should be openly discussed in academic groups with the teacher, it is necessary to be mutually tolerant, to respect the opinion of others. Plagiarism and other forms of dishonest work are not allowed. Inadmissible tips and write-offs during seminars, tests, exams.

Norms of academic ethics: discipline; observance of subordination; honesty; responsibility; work in the classroom with disconnected mobile phones.

Types of control and rating system for evaluation of learning outcomes (RSE)

The following methods and forms of control are used to effectively check the level of mastering by students of higher education of knowledge, skills and abilities in the discipline:

- method of oral control: main questions, additional, auxiliary; questions in the form of a problem; individual, face-to-face and combined surveys;

- method of written control;

- test control method;

- practical control.

Current control is carried out at each practical lesson in accordance with the specific objectives of the topic in order to check the degree and quality of learning. All classes use objective control of theoretical training and practical skills. In the process of current control, the student's independent work on the completeness of tasks, the level of assimilation of educational materials, mastering practical skills of analytical, research work, etc. is evaluated.

Final control - control of educational achievements of higher education students in order to assess the quality of their mastery of the curriculum, which is conducted during the semester certification in the form of an exam. The purpose of the final control is to identify the mastery of the discipline in general, understanding of the educational material, the relationship between the content of educational material, etc.

The final control is carried out in the form of an examination in accordance with the educational program, the individual plan of the applicant for higher education and the working curriculum, developed on the basis of the ONP specialty. At this stage the result of studying and mastering of discipline, skills of use of the received knowledge is summed up.

The final control in the form of an examination is carried out according to the schedule of the credit-examination session.

Postgraduate students who have completed the curriculum and scored at least the minimum number of points are admitted to the final control. A graduate student who, for a good reason, had missed classes, adjustments are made to the individual curriculum and are allowed to work off academic debt until a certain date.

The final control is carried out in a mixed form - written and oral.

The rating of the student from the credit module consists of the points received for: modular control work; practical classes, exam.

System of rating (weight) points and evaluation criteria:

2. Modular control (one MCW)

Weight score - 15 for each of the two tasks of the test.

Criteria for evaluating each of the two tasks:

- "excellent" (not less than 90% of the required information) - 14..15;
- "good" (not less than 75% of the required information) - 12..13;
- "satisfactory" (not less than 60% of the required information) - 10..11
- "unsatisfactory" or the work was not performed - 0.

The maximum number of points for MCW is 15*2 = 30 points.

3. Practical classes

Weight score - 10. Evaluation criteria:

- full performance of all tasks - 9..10;
- incomplete performance of tasks - 6..8;
- tasks were not performed or less than 60% - 0 were performed.

The maximum number of points for performing all tasks in practical classes 1*10 = 10 points.

4. HT

Evaluation criteria:

- full performance of all tasks - 9..10;
- incomplete performance of tasks - 6..8;

- tasks were not performed or less than 60% - 0. The maximum number of points for HT - 10.

5. Penalty and incentive points for:

- Untimely performance of practical work - 2 points;

The sum of penalty and incentive points should not exceed 5.

Rating scale (R):

The sum of weight points of control measures during the semester is

RC = 30+10+10 = 50 points.

Conditions for positive intermediate certification. To receive "credited" from the intermediate certification (8 weeks) the student will have at least 20 points (provided that at the beginning of 8 weeks according to the schedule of control measures "ideal" student must receive 20 points).

To receive "credited" from the intermediate certification (week 14) the student will have at least 16 points (provided that at the beginning of week 14 according to the schedule of control measures "ideal" student must receive 32 points).

The examination component of the scale is equal to 50% of R, namely: $R_E = R\,C\frac{0,5}{1-0,5} = 50$ points.

Thus, the rating scale of the discipline is R = RC + RE = 100 points. A necessary condition for admission to the exam is enrollment in the module test, as well as a starting rating (RC) of at least 40% of the RC, ie 20 points.

Exam evaluation criteria

The ticket contains two questions. The answer to the question is evaluated, depending on the completeness and correctness:

- “excellent”, complete answer (not less than 90% of the required information ……. 23 - 25 points;
- "good", a fairly complete answer (at least 75% of the required information, or minor inaccuracies) .. …… 19 - 22 points;
- “satisfactory”, incomplete answer (not less than 60% of required information and some errors) 15 - 18 points;
- "unsatisfactory", unsatisfactory answer . ..0 points.

The points obtained for each question are added.

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

Scores R	*Rating*
100-95	Perfectly
94-85	Very good
84-75	goode
74-65	satisfactory
64-60	Enough
Less 60	Unsatisfactorily
RC <20 or admission conditions are not met	Not allowed

Work program of the discipline (syllabus):

Compiled by Candidate of Technical Sciences, Associate Professor Vitalii Vitalievich Burnashev

Approved by the Department of CSFV (protocol № 8 of 27.05. 2020)

Approved by the Methodical Commission of IAT (protocol № 2 of 22.06.2020)