Modern methods of designing 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	*Elective*
Form of study	*full-time (day) / full-time (evening) / part-time*
Year of preparation, semester	*2nd year, autumn semester*
The scope of discipline	*5 credits (150 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

Discipline "Modern methods of designing control systems" refers to elective disciplines. It forms students' knowledge in the field of modern theory of automatic control, and is aimed at mastering modern methods of systems synthesis.

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);
- identify, pose and solve research problems in the field of automatic control systems (FC 03);
- to develop models, methods and control algorit ability to develop models, methods and algorithms for controlling aviation, space, robotics and other moving automatic or automated objects (FC 04).

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 the methods of synthesis of control systems, sufficient for conducting 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);
- analyze existing and synthesize new methods and models for diagnosing, maintaining and repairing aircraft control systems (UM 5);
- summarize the results of scientific research in the form of scientific and technical reports, articles, abstracts, monographs, as well as transfer their knowledge, decisions and grounds for their adoption to specialists and non-specialists in a clear and unambiguous form (UM 6).

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 "Innovative methods of design of control systems" requires knowledge and skills that students will receive during the study of disciplines of the second (master's) level of training in specialty 173 " Aivionics": Aircraft control systems (PO1), Orientation systems moving objects (PO4).

The knowledge and skills that graduate students acquire in the process of studying the discipline "Latest methods of designing 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. Methods of identification of mathematical models of dynamical systems	38	2	2		34
Topic 2. Search for optimal trajectories. The principle of maximum.	12	2			10
Topic 3. Analytical design of optimal regulators	12		2		10
Topic 4. Adaptive controllers in aircraft control systems.	16				16

Topic 5. The use of H∞-theory for the synthesis of aircraft control systems	38	2			36
Calculation work	4	2			2
Examination	30				30
Total Hours	150	8	4		138

Training materials and resources

Basic literature:

1. Збруцький О.В., Маляров С.П., Янкелевич Г.Є. Двовимірні гіроскопічні системи керування з симетрією. – Київ: “Політехніка”. – 2019. -120с.

2. Юревич Е.И. Теория автоматического управления. СПб.: «БХВ-Петербург». – 2019. – 560 с.

3. *Пупков К.А., Егупов Н.Д.* Методы классической и современной теории автоматического управления. Том 4: Теория оптимального управления. – М.: МГТУ им. Н. Э. Баумана, 2004. – 748 с.

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

5. *Красовский А.А. Лебедев А.В. Невструев В.В.* Теоретические основы пилотажно-навигационных комплексов. – М.: ВВИА им. Н.Е. Жуковского, 1982. – 374 с.

6. *Берестов Л. JVL, Поплавский Б. К., Мирошниченко Л. Я.* Частотные методы идентификации летательных аппаратов. - М.: Машиностроение, 1985, 184 с, ил.

7. *Пупков К.А., Егупов Н.Д.* Методы классической и современной теории автоматического управления. Том 5: Методы современной теории автоматического управления. – М.: МГТУ им. Н. Э. Баумана, 2004. – 748 с.

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

Additional literature:

9. Интеллектуальная система управления автоматической посадкой беспилотного летательного аппарата на основе комплексного применения технологии нечеткой логики // Авиакосмическое приборостроение. – 2004 г. –№10. – С.30–40.

10. *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.

11. *Михалев И.Л. Окоемов Б.Н.* и др. Системы автоматического управления самолетом. – М.: Машиностроение . 1987. – 240 с.

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

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

14. Babar M. Z., Ali S. U., Shah M. Z., Samar R., Bhatti A. I. and Afzal W. Robust control of UAVs using H∞ control paradigm // *IEEE 9th International Conference on Emerging Technologies (ICET)*, Islamabad, 9-10 December 2013, 1 – 5

15. Jafar A., Fasih Ur Rehman S., Fazal Ur Rehman S., Nisar A. A Robust H infinity control law for unmanned aerial vehicle against atmospheric turbulence // 2nd IEEE International conference on Robotics and Artificial Intelligence (ICRAI), Islamabad 1-2 November 2016, 87 – 92.

16. López J., Dormido R., Dormido S. and Gómez J. P. A Robust *H∞* 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. Methods of identification of mathematical models of dynamical systems** Literature : [1] p.15-28, [11] p.22-29. Tasks on IWS. Review current publications on the identification of mathematical models of aircraft motion
2	**Lecture 2. Application of optimal observer algorithms for identification of mathematical models of aircraft motion** Literature : [1] p.29-33, [10] p.80-84.
3	Lecture 3. **Search for optimal trajectories. Pontryagin's maximum principle** Literature : [1] p.51-56, [10] p.95-99. Tasks on IWS. Review current publications on the synthesis of optimal flight trajectories of aircraft.
4	**Lecture 4. Robust regulators. Synthesis of H∞-suboptimal regulator** Literature: [2] p.76-88, [13] p.115-146. Tasks on IWS. Review current publications on the synthesis of robust aircraft regulators. Pay attention to weight functions

Practical classes

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

1. Identification of the parameters of the mathematical model of the aircraft by the algorithm of the linear optimal observer.
2. Modular control work

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)

Course policy (educational component)

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 MCR)

Weight score - 20 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) - 18..20;
- "good" (not less than 75% of the required information) - 15..17;
- "satisfactory" (not less than 60% of the required information) - 12..14.
- "unsatisfactory" or the work was not performed - 0.

The maximum number of points for MCR is 20*2 = 40 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. 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 = 40 + 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: $R_E = RC\frac{0,5}{1-0,5}$ = 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)