National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Department
biomedical engineering

DESIGN of AUNOMATIC CONTROL SYSTEMS

Working program of educational discipline (Syllabus)

Requisites of the Course	
Cycle of Higher Education	***First (bachelor's)***
Branch of knowledge	*16 Chemical and Bioengineering*
Specialty	*163 Biomedical Engineering*
Educational program	*Medical Engineering*
Course status	*Mandatory*
Mode of study	*full-time / day / mixed / remote*
Year of study/Semester	*3 year (autumn / fall semester)*
ECTS workload	*4 ECTS credits / 120 hours*
Testing and Assessment	*Final Test, Module Test*
Course schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about course supervisor / teachers	***Lecturer:*** *senior teacher off Department of BMI Zubkov Stanislav Vladimirovich, e-mail – szub284@gmail.com, Telegram - Stanislav Zubkov, +380962212622* ***Practice:*** *senior teacher off Department of BMI Zubkov Stanislav Vladimirovich, e-mail – szub284@gmail.com, Telegram - Stanislav Zubkov, +380962212622*
Course placement	*own resource: https://drive.google.com/drive/folders/1awt89uSkuKr4HC4ioURpiA2OebDvsLo6?usp=sharing*

Distribution of hours				
Semester	**Lectures**	**Practical**	**Laboratory**	**Self-study**
Autumn/fall semester	*28*	*44*	*-*	*46*

Outline of the Course

1. Course description, goals, objectives, and learning outcomes

The discipline "Design of automatic control and management systems" studies the application of methods and general principles of construction, modern methods of analysis, synthesis, calculation and research of automatic control systems (ACS) related to the development and engineering of biological and medical devices and systems.

The main purpose of the discipline "Design of automatic control and management systems" is the formation of students' ability to solve complex specialized problems, apply modern technologies of analysis and synthesis of ACS, software, knowledge of standards and technical characteristics of ACS elements, ability to use this knowledge in product design medical purpose.

Training in the discipline "Design of automatic control and management systems" is carried out on the basis of student-centered approach and strategy of interaction between teacher and student in order for students to master the material and develop their practical skills.
Since the discipline is selective, its study requires:
skills: methods of programming simulation and analysis of technical and biological systems; methods of the theory of automatic control of analysis and synthesis of automatic systems, units of diagnostic devices and devices; possession of MicroCap-12 software.
Competences: As a result of studying the discipline students will be able to:
- to understand and use the tools and methods of analysis and synthesis of ACS;
- to know the basics of ACS theory;
- to be able to use technical and software tools for designing ACS;
-to be able to search and summarize information on the development of YES and apply it within its competence;
to conduct research using modern software tools for process simulation, including biological systems.
And also practically to use the acquired knowledge from:
- typical models of units and ACS and the main properties of dynamic objects and systems (regardless of their physical nature);
- methods of structural analysis of ACS;
- methods of synthesis of ACS;
- mathematical apparatus for compiling mathematical models of ACS, individual parts of medical equipment and biological objects;
- methods of identification of technical and biological systems;
- analysis of transients in the ACS;
- properties of frequency characteristics, phase portraits of systems;
- evaluation criteria and methods to ensure the sustainability of ACS;
- methods of using models of industrial products to model the operation of medical systems;
- compilation of elementary models of organs and systems of the human body.
- general principles and trends in the development of modern control systems, modern controls.
- formulation and substantiation of technical requirements to ACS;
- application of ACS analysis methods for research of technical and biological systems;
- interpretation of biological objects as a complex of functional and dynamic links;
- use of regulatory laws to synthesize the desired transfer function;
- use of modern theoretical methods and technical means to determine the parameters of technical and biological systems;
- modeling of processes that take place in medical devices, apparatus and biological objects and systems;
- determination of the optimal structure of the ACS, the criteria for their evaluation under restrictions;
- calculation of the principles of operation of various systems of the human body in terms of the theory of automatic control.
***General competencies** (OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

***GC 1** - Ability to apply knowledge in practical situations.*
***GC 2** - Knowledge and understanding of the subject area and understanding of professional activity.*
***GC 6** – Ability to searching, process and analyze information from various sources.*
***GC 7** – Ability to generate new ideas (creativity).*
***GC 8** – Ability to make well-grounded decisions.*

***Special (professional) competencies** (OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

***PC 1 -** Ability to use engineering software packages for research, analysis, processing and presentation of results, as well as for automated design of medical devices and systems.*
***PC 3 -** Ability to study and apply new methods and tools for analysis, modeling, design and*

optimization of medical devices and systems.

PC 5 - *Ability to apply physical, chemical, biological and mathematical methods in the analysis, modeling of the functioning of living organisms and biotechnical systems.*

PC 12 - *Ability to develop, plan and apply mathematical methods in the analysis, modeling of the functioning of living organisms, systems and processes in biology and medicine.*

PC 14 - *Ability to conduct experiments according to specified technical and medical methods, perform computer processing, analysis and synthesis of the results.*

The program learning outcomes after studying the discipline "Design of Automatic Control Systems" *are (OPP was put into effect by the Rector's Order NON/ 89/2021 of 19.04.2021):*

PLO 3 - *Possession of modern methods of scientific research software, construction of adequate theoretical models and methods of their substantiation.*

PLO 7 - *Possession of methods of research, design and construction of biomedical equipment, analysis and processing of experimental data.*

PLO 10 - *Knowledge in the most advanced fields of education and professional activity and at the junction of different fields.*

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

Course "Design of Automatic Control Systems" belongs to the cycle of professional training and has an interdisciplinary nature. It integrates according to its subject knowledge from other disciplines: Higher Mathematics, Fundamentals of Informatics, Theory of Biomedical Signals, Fundamentals of Discrete Mathematics, Mathematical Modeling of Biomedical Processes and Systems. According to the structural and logical scheme of the training program, the discipline "Design of automatic control and management systems" is closely related to other disciplines of training: Analysis and design of electronic medical equipment, undergraduate practice and diploma design.

3. Course Overview

The main parts and subjects that will be considered in the process of studying the course:

Section 1. Basic concepts of the theory of automatic control

Topic 1.1. Classification of automatic control systems.
Topic 1.2. Typical input signals. Laplace transform.
Topic 1.3. Transfer function. Structural transformations.

Section 2. Typical links of automatic control systems

Topic 2.1. Frequency characteristics of typical links.
Topic 2.2. Logarithmic frequency characteristics of typical links.
Topic 2.3. Time characteristics of typical links.

Section 3. Stability of automatic control systems

Topic 3.1. Determination of stability by Lyapunov. Basic theorems.
Topic 3.2. Phase space method. Phase portraits of systems.
Topic 3.3. Criteria of stability.

Section 4. Synthesis of automatic control systems

Topic 4.1. The order of synthesis and main indicators.
Topic 4.2. Direct quality indicators. Coefficients of error.

Topic 4.2. Indirect quality indicators. Optimal systems. Synthesis of PID-regulator.

Section 5. Mathematical models of technical and biological units

Topic 5.1. Mathematical models of technical units.
Topic 5.2. Mathematical models of biological units.

4. Coursebooks and teaching resources

Basic:

1. Солодовников В.В. Техническая кибернетика, книги 1 и 2. Теория автоматического регулирования. М., «Машиностроение», 1967 г.

2. Бесекерский В.А., Попов Е.П. Теория систем автоматического регулирования. М. «Наука», 1975 г. 767 стр. с илл.

3. Ордынцев В.М. Математическое описание объектов автоматизации. М., «Машиностроение», 1965г., 360 стр. с илл.

4. Разевиг В.Д. Схемотехническое моделирование с помощью Micro-CAP 7. «Горячая линия-Телеком», 2003 г. 368 с.

5. Micro-Cap 7.0 Electronic Circuit Analysis Program Reference Manual Copyright 1982-2001 by Spectrum Software 1021 South Wolfe Road Sunnyvale, CA 94086.

6.Амелина М.А. Конспект лекций по курсу «Компьютерный анализ и синтез электронных устройств (часть 1)». Кафедра «Промышленная электроника», «Московский энергетический институт» (технический университет) в г. Смоленске. 2005 г.

7. Витвицька Л. А. Теорія автоматичного керування: конспект лекцій / Л. А. Витвицька, Ю. М. Кучірка. – Івано-Франківськ: Івано-Франківськівський національний технічний університет нафти і газу, 2015. – 54 с.

Supplementary:

1. Воронич А. Р. Основи автоматичного керування технічними об'єктами: конспект лекцій / А. Р. Воронич. – Івано-Франківськ: ІФНТУНГ, 2015. – 125 с.

2. Автоматичне управління: конспект лекцій / Г. Н.Семенцов, Я. Р. Когуч, М. І. Когутяк, М. І. Горбійчук. – Івано-Франківськ: ІФНТУНГ, 2003. – 398 с.

3. Сав'юк, Л. О. Теорія автоматичного управління : методичні вказівки / Л. О. Сав'юк, Р. М. Матвієнко. - Івано-Франківськ : ІФНТУНГ, 2006. - 66 с.

4. Сав'юк, Л. О. Теорія автоматичного управління : конспект лекцій / Л. О. Сав'юк. - Івано-Франківськ : ІФНТУНГ, 2017. - 69 с.

5. Семенцов, Г. Н. Теорія автоматичного управління (нелінійні та дискретні системи) : навч. посіб. / Г. Н. Семенцов, І. І. Чигур. - Івано-Франківськ : ІФНТУНГ, 2014. - 96 с.

6. Белей, С. М. Вступ в теорію систем : практикум / С. М. Белей, С. П. Ващишак. - Івано-Франківськ : ІФНТУНГ, 2011. - 27 с.

7. Інтегровані та адаптивні системи керування : конспект лекцій / Г. Н. Семенцов, І. І. Чигур, Я. Р. Когуч, М. М. Дранчук. - 2-е вид. - Івано-Франківськ : ІФНТУНГ, 2010. - 65 с.

8. Бурганова Л.А. Теория управления: учебное пособие / Л.А. Бурганова – М.: Инфра, 2009. – 153 с.

9. Методы классической и современной теории автоматического управления: Учебник в 5-ти тт.; 2-е изд., перераб. и доп. Т.1: Математические модели, динамические характеристики и анализ систем автоматического управления / Под ред. К.А. Пупкова и Н.Д. Егупова. М.: Изд-во МГТУ им. Н.Э. Баумана, 2004. – 656 с.

10. Методы классической и современной теории автоматического управления: Учебник в 5-ти тт.; 2-е изд., перераб. и доп. Т.2: Статистическая динамика и идентификация

систем автоматического управления /Под ред. К.А. Пупкова и Н.Д. Егупова. М.: Изд-во МГТУ им. Н.Э. Баумана, 2004. – 640с.

11. Дубовик В.П., Юрик І.І. Вища математика:Навч.посібн. – К.: А.С.К., 2006. – 648 с.

В. С. Герасимчук, Г. С. Васильченко, В. І. Кравцов, Вища математика. Повний курс у прикладах і задачах: навч. посіб. [Ч.1]. Лінійна й векторна алгебра. Аналітична геометрія. Вступ до математичного аналізу. Диференціальне числення функцій однієї та багатьох змінних. Прикладні задачі/ - К.: Книги України ЛТД, 2009. - 578 с

Educational content

5. Methods of mastering the discipline (educational component)

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
1.	Topic 1.1. Classification of medical devices. Metrological characteristics of medical devices.	PLO3 PLO7 PLO 10	Practice 1	1 week
2.	Topic 2.1. Theoretical foundations of electrocardiographs.	PLO3 PLO7 PLO 10	Practice 2,3	2 week
3.	Topic 2.2. Design and technical characteristics of electrocardiographs.	PLO3 PLO7 PLO 10	Practice 4	3 week
4.	Topic 3.1. Theoretical foundations of electroencephalographs.	PLO3 PLO7 PLO 10	Practice 5,6	4 week
5.	Topic 3.2. Design and technical characteristics of electroencephalographs.	PLO3 PLO7 PLO 10	Practice 7	5 week
6.	Topic 4.1. Theoretical foundations of pulseoximeters.	PLO3 PLO7 PLO 10	Practice 8,9	6 week
7.	Topic 4.2. Design and technical characteristics of pulseoximeters.	PLO3 PLO7 PLO 10	Practice 10	7 week
8.	Topic 5.1. Theoretical foundations of blood pressure.	PLO3 PLO7 PLO 10	Practice 11,2	8 week
9.	Topic 5.2. Design and technical characteristics of blood pressure monitors.	PLO3 PLO7 PLO 10	Practice 13	9 week
10.	Topic 6.1. Theoretical foundations of reographers.	PLO3 PLO7 PLO 10	Practice 14,15	10 week
11.	Topic 6.2. Design and technical characteristics of reographs.	PLO3 PLO7 PLO 10	Practice 16	11 week
12.	Topic 7.1. Theoretical foundations of phonocardiographs	PLO3 PLO7 PLO 10	Practice 17,18	12 week
13	Topic 7.2. Design and technical characteristics of phonocardiographs.	PLO3 PLO7 PLO 10	Practice 19	13 week
14	Topic 8.1. Theoretical foundations of ultrasonic devices.	PLO3 PLO7 PLO 10	Practice 20	14 week
15	Module Test	PLO3 PLO7	-	14 week

		PLO 10		
16	Final Test	PLO3 PLO7 PLO 10	-	14 week

6. Self-study

One of the main types of semester control during the mastering of the discipline "Design of Automatic Control Systems" is preparation for lectures, practical works, express control works / test tasks and personal control tasks.

Policy and control

7. Attendance policy

Attending classes

Attendance at lectures (consultations) is highly recommended, as well as mandatory independent preparation for lectures. Attendance at practical classes is mandatory, as they are used to write express tests / tests / defense of practical work, grades for which are included in the current rating.

The assessment system is focused on obtaining points for student activity, as well as personal homework that can develop practical skills.

Control measures missed

Missed control measures for the protection of practical work must be worked out if there is a report at the next lesson, or at consultations.

Omissions of writing a module test and express test are not fulfilled. Skipped Module Test can be worked out in consultations.

Violation of deadlines, penalty points and rewarding points

Rewarding points		Penalty points*	
Criterion	Weight points	Criterion	Weight points
Practical or laboratory work improvement	1 point (for each work)	Untimely implementation of a practical work	From -0.5 points to -5 points (depending on the delivery date)
Online courses completed on the topics that are agreed with the teacher	5 points	Untimely implementation of a laboratory work	From -0.5 points to -5 points (depending on the delivery date)
Registration of scientific work for participation in the competition of student scientific works	10 points	Untimely implementation of a Module Test	From -0.5 points to -5 points (depending on the delivery date)
Writing of abstracts, articles, participation in international, national and / or other events or competitions on the subject of the Course	From 5 points to +10 points	Untimely implementation of a Home Control Work	From -2 points to -5 points (depending on the delivery date)

** if the control measure was missed for a good reason (illness, which is confirmed by a certificate of the established sample) - penalty points are not accrued.*

Academic integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Norms of ethical behavior

Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read

more: https://kpi.ua/code.

Procedure for appealing the results of control measures

Students have the opportunity to raise any issue related to the control procedure and expect it to be addressed according to predefined procedures.

The student has the right to appeal the results of the control measure according to the approved provision on appeals in the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (approved by the order №NON/128/2021 from 20.05.2021) - https://osvita.kpi.ua/index.php/node/182

Inclusive education

The course "Design of Automatic Control Systems" can be taught to the most of students with special educational needs.

Distance learning

Distance learning takes place through the Sikorsky Distance learning Platform «Sikorsky».

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express control / test tasks, practical work).

Performance of practical works, and also performance and defense of a Home Control Work is carried out during self-study work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).

Teaching in a foreign language

Teaching in English is carried out only for foreign students.

At the request of students, it is allowed to study the material with the help of English-language online courses on topics that correspond to the topics of specific classes.

8. Monitoring and grading policy

Grading system (current control):

№ s/n	Control measure	%	Weight points	Number	Total
1.	Report on the implementation of practical work	0	0	20	Condition of admission
2.	Express control works / test tasks / defense of practical works	40	2	20	40
3.	Personal control task №1	10	10	1	10
4.	Personal control task №2	10	10	1	10
5.	Modular control work	20	20	1	20
6.	Final Test	20	20	1	20

	Total	*100*

The applicant receives a positive credit score for the results of the semester, if he has a final rating for the semester of at least 60 points and has met the conditions of admission to the semester control, which are determined by the RSO.
With applicants who have met all the conditions of admission to the test and have a rating of less than 60 points, as well as with those applicants who want to increase their rating, the penultimate on the schedule of the discipline in the semester teacher conducts semester control in the form of modular control / test task.
If the grade for the modular test is less than the current rating, the "hard" RSO is used - the previous rating of the applicant according to item 2 (except for points for the semester individual task, items 3 and 4) is canceled and he receives a grade based on test results. work. This option forms a responsible attitude of the applicant to the decision to perform the test, forces him to critically assess the level of his training and carefully prepare for the test.

Calendar control *(CC) is performed twice a semester as monitoring of the current state of compliance with syllabus requirements.*

The purpose of calendar control is to improve the quality of student learning and monitor the implementation of the schedule of the educational process by students.

Criterion			*The first CC*	*The second CC*
Deadline of calendar controls			*8th week*	*14th week*
Requirements to obtain a positive calendar control	*Current grade*		*≥ 21 points*	*≥ 37 points*
	Report on the implementation of practical work	*Pr No.1-12*	*+*	*+*
		Pr No.13-20	*-*	*+*
	Express control works / test tasks / defense of practical works	*Minimum 50% of possible points on topics 1.1… 3.2*	*+*	*+*
		Minimum 50% of possible points on topics 3.3… 5.2	*-*	*+*
	Personal control task №1	*according to sections 1,2*	*+*	*+*
	Personal control task №2	*according to section 4*	*-*	*+*
	Modular control work		*-*	*+*

In the case of a plagiarism or an academic poor quality during training the control measure is not credited.

Semester certification of students

Mandatory requirements for the admission to the Final Test		*Criterion*
1	*Current grade*	*RD ≥ 60*
2	*All laboratory works are completed*	*Report*
3	*Writing at least 5 express tests / tests*	*More than 24 points*

The results are announced to each student separately in the presence or remotely (by e-mail). It is also recorded in the "Electronic Campus" system.

Optional requirements for the admission to the Final Test:

1. *Active work during practical classes.*
2. *Positive result of the first and the second calendar control.*
3. *Attending of lectures.*

The final performance score or the results of the Final Test are adopted by university grading system as follows:

Number points	*Assessment on the university scale*
100-95	*Excellent / Відмінно*
94-85	*Very good / Дуже добре*
84-75	*Good / Добре*
74-65	*Satisfactory / Задовільно*
64-60	*Satisfactory / Достатньо*
Less 60	*Unsatisfactory / Незадовільно*
The course requirements are not met	*Not allowed / Не допущено*

9. Additional information on the course (educational component)

Module Test (MT), which is planned for the course and is designed for a total of two academic hours, is conducted in two practical classes.

The list of questions for preparation for Module Test, and also for preparation for credit is given in appendix 1.

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express tests, practical work).

Work pgram of the course (syllabus):

***is developed by Senior Lecturer**, Stanislav Zubkov.*

***Approved by** the Department of Biomedical Engineering (protocol № ___ to _____)*

***Approved by** the Methodical Commission of the Faculty of Biomedical Engineering (protocol № __ to _____)*

Appendix 1 to the syllabus of the course
"Design of Automatic Control Systems"

The list of questions for preparation for the Module Test, Final Test

1. Classification of ACS.

2. The transfer function of the link.

3. General structural scheme of ACS.

4 Communication between ACS and SAR.

5. Elementary and typical dynamic links.

6. Decomposition of the transfer function, consisting of the transfer functions of typical units.

7. The transfer function of a closed system on the input influence.

8. The transfer function of a closed system by error.

9. The transfer function of a closed system on the disturbing effect.

10. Conversion of a chain of series-connected links to one link.

11. Transformation of a chain of parallel connected links to one link.

12. Transfer of the node through the link along and against the movement of the signal.

13. Transfer of the adder through the adder along and against the movement of the signal.

14. Typical input effects.

15. The only transient and impulse transient characteristic.

16. Amplifier link, its equation of dynamics, transfer function, type of transient characteristic.

17. Aperiodic link, its equation of dynamics, transfer function, type of transient characteristic.

18. Oscillatory link, its equation of dynamics, transfer function, type of transient characteristic.

19. Conservative link, its equation of dynamics, transfer function, type of transient characteristic.

20. Frequency characteristics of the links (according to the known transfer function of the link).

21. AFCHH, LACHH and LFCHH of the amplifying link.

22. AFCHH, LACHH and LFCHH aperiodic link.

23. AFCHH, LACHH and LFCH oscillating link.

24. LACHH and LFCHH of an ideal differentiating link.

25. LACHH and LFCHH forcing link.

26. General solution of the equation of ACS dynamics (free and forced components).

27. Laplace transform. Basic properties.

28. Differentiation and integration of the original.

29. Theorems on delay and displacement

30. Theorems on initial and final value.

31. Image of □-function, unit step function, linear function.

32. Image of the exponent by Laplace.

33. Laplace image kSin□t

34. Laplace image kCos□t

35. *Decomposition formula for a fine-rational function.*
36. *Theorem of existence and uniqueness of the solution of a differential equation.*
37. *Determination of Lyapunov stability.*
38. *Determination of asymptotic stability according to Lyapunov.*
39. *Determination of instability by Lyapunov.*
40. *Derived by virtue of the system. Lyapunov functions.*
41. *Phase space method. Phase portrait.*
42. *Properties of phase trajectories. Types of phase trajectories (list).*
43. *Phase portrait of the "node" type.*
44. *Phase portrait of the type "saddle".*
45. *Phase portrait of the type "focus", "center".*
46. *Reduction of stability. Theorem 1.*
47. *Theorem 2 (on boundedness of solutions).*
48. *Theorem 3 (on asymptotic stability).*
49. *Theorem 4 (on stability at Re□k = 0).*
50. *Hurwitz criterion.*
51. *The principle of argument.*
52. *Mikhailov's criterion.*
53. *The rule of alternation of roots as a consequence of the Mikhailov criterion.*
54. *Nyquist criterion for the case of SAR, stable in the open state.*
55. *Nyquist criterion for the occasion of SAR, unstable in the open state.*
56. *Rule on the number of transitions through the critical segment [-□, -1].*
57. *Nyquist criterion for astatic systems (adding a circle with R = ()*
58. *Stocks of stability.*
59. *Definition of the concept of astatism SAR.*
60. *Representation of the error SAR as the sum of errors in position, speed and acceleration.*
61. *Calculation of error rates C0, C1, C2.*
62. *Direct indicators of the quality of the transition process.*
63. *The relationship of integrated quadratic quality assessment of SAR with Butterworth functions.*
64. *General view of the structure of the SAR with PID - regulator.*
65. *Synthesis of serial KU (PID - regulator).*
66. *Synthesis of parallel KU.*
67. *Invariance with respect to the input effect.*
68. *Invariance with respect to outrageous influence.*
69. *Desirable transfer function with polynomial root distribution.*
70. *Linearization of differential equations.*

71. DC motor, system of its differential equations, transfer functions on input influence and on perturbation.

72. General equation of a section of a line with concentrated parameters.

73. General equation of a section of a line with distributed parameters.

74. Frank's model for the vessel section and the 3-element equivalent Windkessel model.

75. The equation of continuity.

76. Euler's equation for the vessel area and their electrodynamic analogue