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

Department of Automation of Electrotechnical and Mechatronic Complexes

# Engineering of electrotechnical and mechatronic systems. Course project

## Working program of the educational discipline (Syllabus)

| Detail of educational discipline | |
|---|---|
| **Level of higher education** | ***Second (Master's)*** |
| **Branch of knowledge** | *14 Electrical engineering* |
| **Specialty** | *141 Power engineering, electrical engineering and electromechanics* |
| **Educational program** | *Engineering of intelligent electrotechnical and mechatronic complexes* |
| **Discipline status** | *Normative* |
| **Form of education** | *daytime* |
| **Year of training, semester** | *1st year, spring semester* |
| **Scope of the discipline** | *1,5 credits (45 hours)* |
| **Semester control/ control measures** | *Test* |
| **Schedule** | |
| **Language of teaching** | *English* |
| **Information about course teachers** | Lecturer: Ph.D., associate professor, Anton V.Toropov, tel. 066-736-54-53, email: toropovtosha@ukr.net<br>Practical / Seminars: Ph.D, associate professor, Anton V.Toropov, tel. 066-736-54-53, email: toropovtosha@ukr.net |
| **Placement of course** | https://classroom.google.com/c/NTU3ODQwNzM2MjM4 |

## Program of educational discipline

### 1. Description of the educational discipline, its purpose, subject of study and learning outcomes

The purpose and tasks of the educational discipline "Engineering of electrical and mechatronic systems. Course project" - to acquaint students with the basic provisions of consulting and investment and construction engineering. In the process of studying the discipline, students learn the basics of organizing project work, get acquainted with the basic schemes of electric drives, methods of organizing construction, assembly, and commissioning work in the construction of electrotechnical complexes and mechatronic systems.

Competencies: (C01) Ability to search, process and analyze information from various sources; (C02) Ability to use information and communication technologies; (C03) Ability to apply knowledge in practical situations; (C05) Ability to make informed decisions; (C08) Ability to work independently and in a team; (C11) Ability to apply existing and develop new methods, techniques, technologies and procedures for solving engineering tasks of electric power, electrical engineering and electromechanics; (C14) Ability to demonstrate knowledge and understanding of mathematical principles and methods required for use in electrical power, electrical engineering, and electromechanics; (C18) Ability to demonstrate awareness and ability to use normative legal acts, norms, rules and standards in electric power, electrical engineering and electromechanics; (C19) Ability to use software for computer modeling, automated design, automated production and automated development or construction of elements of electric power, electrotechnical and

electromechanical systems; (C22) Ability to develop means, methods and methods of science and technology aimed at automating existing and creating new automated and automatic technologies and productions; (C23) Ability to optimize technological processes and build structural diagrams of intelligent automated control systems.

Program learning outcomes: (PR01) Reproduce processes in electric power, electrotechnical and electromechanical systems during their computer simulation; (PR03) Analyze processes in electric power, electrotechnical and electromechanical equipment and corresponding complexes and systems; (PR05) To have the methods of mathematical and physical modeling of objects and processes in electric power, electrotechnical and electromechanical systems; (PR06) Search for sources of resource support for additional training, scientific and innovative activities; (PR16) Choose the element base of electromechanical and mechatronic systems, complete electric and hydraulic drives, control, protection, automation systems of power supply of machines and installations, production sites and enterprises.

## 2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

Interdisciplinary connections: The discipline "Engineering of electrical and mechatronic systems. Course project " is taught on the basis of the material of the disciplines: «Automated electric drive of machines and installations», «Computer modeling of processes in electromechanical systems», «Digital and nonlinear systems of electric drive control», «Intelligent decision-making systems», etc., which students studied earlier or in parallel.

The knowledge and skills acquired in the process of studying the credit module «Engineering of electrical and mechatronic systems. Course project» are necessary for every specialist of this specialty who solve engineering tasks in the field of automation of electrical engineering and mechatronics and when completing a master's thesis.

## 3. Educational materials and resources

**Primary literature:**


1. Bolton, W. (2018). Mechatronics. Great Britain: Pearson Education Limited.
2. Bolton, W. (2020). Engineering Science. Great Britain: CRC Press.
3. Biemer, S. M., Kossiakoff, A., Seymour, S. J., Flanigan, D. A. (2020). Systems Engineering Principles and Practice. Great Britain: Wiley.
4. Drive Solutions Mechatronics for production and logistics. Edited by E. Kiel.–Berlin: SpringerVerlag, 2008. – 542 p.
5. The industrial communication technology handbook Edited by Richard Zurawski.: CRC Press, Taylor & Francis Group. 2005. - 879 p, ISBN 0-8493-3077-7
6. MATLAB for Engineering Applications. Edited by William J. Palm: McGraw-Hill Education, 2019. – 563p. https://www.technicalbookspdf.com/download/?file=17617


**Secondary literature:**


6. Alexander Kossiakoff, Samuel J. Seymour, David A. Flanigan, Steven M. Biemer. (2020) Systems Engineering Principles and Practice. John Wiley & Sons, Inc– 688p. ISBN: 978-1-119-516668
7. W.Bolton (2018) Mechatronics: Electronic control systems in mechanical and electrical engineering. Seventh edition: Pearson Education Limited – 648p. ISBN-13: 9781292250977 https://www.pearson.com/en-us/subject-catalog/p/mechatronics-electronic-control-systems-in-mechanical-and-electrical-engineering/P200000003775/9781292250977
8. International Standard IEC 61131-1 Programmable controllers –Programming languages https://webstore.iec.ch/preview/info_iec61131-1%7Bed2.0%7Den.pdf

9. International Standard IEC IEC 61800-3 Adjustable speed electrical power drive systems –EMC requirements and specific test methods https://webstore.iec.ch/p-preview/info_iec61800-3%7Bed3.0.RLV%7Den.pdf

*Literature, the bibliography of which is provided with a link, can be found on the Internet. Literature, the bibliography of which does not contain references, can be found in the library of KPI named after Igor Sikorsky. Basic literature [1]-[4] is mandatory for reading. All other literary sources are optional, it is recommended to familiarize yourself with them.*

## Educational content

### 4. Methods of mastering an educational discipline (educational component)

Strategies of active learning are applied, which are determined by the following methods and technologies: problem-based learning methods (research method); the following methods are used when completing the course project: problem-search method, work with educational and methodological literature and information resources, independent work.

| ***The week of the semester*** | ***The name of the stage of work*** |
|---|---|
| 1 | Getting a topic and task |
| 2 | Selection and analisys of literature |
| 3-4 | Marketing research of existing electrotechnical and electromechanical systems on the market of Ukraine according to topic of cource project |
| 5-6 | Selection of the automated control system for the design object according to topic of cource project |
| 7-8 | Calculation of operating modes and selection of electric drive components. Selection of switching electrical equipment |
| 9-10 | Evaluation of energy efficiency indexes and control characteristics of the selected electromechanical system |
| 11-12 | Selection of hardware and software tools for system automation |
| 13-14 | Synthesis of the electric drive control system using the MATLAB or other similar software |
| 15 | Designing of wiring diagram of an electric drive |
| 16 | Feasibility study of the design solution |
| 17 | Formalization of graphic materials |
| 18 | Cource project defense |

**Tasks for the course project**

For all students, one general title of the topic of the course project "Engineering of electrical and mechatronic systems" is offered. The specific mechanism is agreed with the supervisor of the course project. The recommended list of design objects is as follows:

1. Lifting machines and various types of similar installations.
2. Conveyor systems.
3. Turbomechanisms: fans, pumps, compressors.
4. Single-bucket excavators: mechanical shovels, draglines.
5. Rotary excavators.

6. Drilling machines.
7. Mining harvesters.
8. Elevator installations.
9. Objects of civil structures.

Course projects could also be carried out for other design objects that correspond to the profile of graduate training in 141 specialties, which is determined by the project supervisor at the initiative of students, scientific supervisors of master thesis or third-party organizations, including stakeholders.

The initial data for the design is formed by project supervisor after choosing a specific machine or installation, considering the current state in the relevant industry.

**Content of the course project**

1. The graphic part should be presented in electronic and paper formats at two drawings of A1 format, drawn up according IEC standards.

2. Explanatory note - 20-40 pages of printed text in A4 format, designed in accordance with IEC standards.

Material that can be located on the graphic part:

- general view of the installation or complex with overall dimensions;
- speed and load diagrams of the production mechanism;
- mechanical and electromechanical characteristics of the electric drive;
- static characteristics of the investigated object;
- electric drive coordinates transients;
- technological parameters transients;
- automation scheme of technological processes;
- basic electrical or electrical wiring diagram;
- the results of using CAD or CAE systems.

**The content of the explanatory note**

1. Marketing research of existing electrotechnical and electromechanical systems on the market of Ukraine according to topic of cource project.
2. Selection of an automated control system for the selected object according to topic of cource project
3. Calculation of operating modes and selection of electric drive components. Selection of switching electrical equipment.
4. Evaluation of energy indicators and control characteristics of the selected electromechanical system.
5. Selection of technical and software tools of automation systems.
6. Synthesis of the electric drive control system using the MATLAB or other similar software.
7. Description of the operation of the system according to the electrical diagram.
8. Feasibility study of the design solution.

### 5. Independent work of the student

Independent work of the student involves:
preparation CP - 46 hours.

## Policy and control

### 6. Policy of educational discipline (educational component)

The policy of the educational credit module is based on the corporate policy of KPI named after Igor Sikorsky. KPI named after Igor Sikorskyi is a free and autonomous center of education, which is called to give adequate answers to the challenges of modern times, to nurture and protect the spiritual freedom of a person, which makes him able to act according to his own conscience; its civil freedom, which

is the basis of the formation of a socially responsible personality, and academic freedom and integrity, which are the main driving factors of scientific progress. The internal atmosphere of the University is built on the principles of openness, transparency, hospitality, and respect for the individual.

The result of completing the course work should be the acquisition of skills and abilities to build a control system for a certain technological process. The applicant's answer must demonstrate signs of independent performance of assigned tasks, absence of signs of repetition and plagiarism.

A student of higher education must adhere to educational and academic ethics and the schedule of the educational process; to be considered, attentive.

## 7. Types of control and rating system for evaluating learning outcomes (RSE)

**Current control:** Checking sections of the CP .

**Calendar control:** is carried out twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the corresponding calendar control.

**Semester control**: test.

1. The student's rating from the educational component is calculated out of 100 points.

The course project rating has two components. The first (starting) characterizes the student's work on course design and its result - the quality of the explanatory note and graphic material. The second component characterizes the quality of the student's defense of the course project.

The scale of the starting component is 40 points, and the defense component is 60 points.

A. Starting component (RC):

- timeliness of course design schedule implementation - 5-3 points;
- modernity and justification of the decisions made - 12-7 points;
- correct application of analysis and calculation methods - 10-6 points;
- quality of registration, compliance with the requirements of regulatory documents - 6-4 points;
- quality of graphic material and compliance with standards - 7-4 points.

B. Course project defense component (RD):

- completeness of the analysis of possible options - 10-6 points;
- degree of mastery of the material - 15-9 points;
- the degree of substantiation of the decisions made - 15-9 points;
- the ability to defend one's opinion - 20-12 points.

2. The student's rating is defined as the sum of ratings for each type of educational activity, both the main (mandatory) and additional types of work for the credit module during the semester, taking into account incentive and penalty points.

After completing the credit evaluation, the rating score (total rating score) RD=RC+RE is determined.

In order for the student to receive the appropriate grade from the credit module (ECTS and traditional), his rating grade RD is translated according to the table:

| Number of points | Rating |
|---|---|
| 100-95 | Excellent |
| 94-85 | Very good |
| 84-75 | Good |
| 74-65 | Satisfactory |
| 64-60 | Enough |
| Less than 60 | Unsatisfactory |
| The conditions of admission are not fulfilled | Not allowed |

## 8. Additional information on the discipline (educational component)

The list of questions submitted for semester control is given in the appendix to the syllabus.

**Working program of the educational discipline (syllabus):**

**Developed by:** Associate Professor of the Department of Automation of Electrical and Mechatronic Complexes, Ph.D., Anton V. Toropov

**Approved by:** Department of Automation of Electrical and Mechatronic Complexes. (Protocol No.18 from 20.06.23).

**Agreed by:** Methodical Commission of Educational and scientific institute of energy saving and energy management (Protocol No.xx from xx.06.23).

**Appendix to the syllabus of the educational component of the course «Engineering of electrical and mechatronic systems»**

**The list of tasks submitted for semester control**

1. Explain the concepts of engineering and electromechatronics.

2. Formulate the main types of activities in the implementation of engineering of electromechatronic systems (electric drives and automation systems).

3. List the possible types of engineering activities for young specialists.

4. Reveal the meaning of the following generally accepted terms: stage of creation, product, production, production, plant (factory), enterprise, firm, organization.

5. List the objects of system engineering; the main stages of the process of development and production of products and production.

6. List the main functions of the customer, developer and manufacturer.

7. Give examples of methods of unification, aggregation and typification in system engineering.

8. Formulate the main objects and components of electrical engineering.

9. Formulate the main provisions that must be followed when implementing power equipment projects; the procedure for solving design issues in accordance with the technical specifications.

10. What do the main regulatory documents used in electrical engineering regulate?

11. Give options for creating automated electric drives; principles of construction of modern automated technological complexes (typical structure).

12. Reveal the general issues of calculation, selection and design of automated electric drives.

13. Explain the main options for implementing projects to modernize existing equipment in automated electric drives.

14. List the main requirements for the analysis and selection of the optimal option of an electromechatronic system.

15. Explain the concept of synthesis of means of electromechatronic systems (electric drives and automation systems).

16. Explain the main stages, goals and results of creating distributed automation systems.

17. Give an example of a scheme of means of a modern complex automation system.

18. Explain the purpose and structure of a business plan for an investment project.

19. Explain the content of marketing research.

20. Explain the concept of standard; goals of standardization.

21. Provide the basic concepts and regulations regarding certification.

22. Explain the concept of licensing of certain activities.

23. Give examples of the organizational structure of modern engineering firms.

24. Explain the concepts of agreements and contracts, their content.

25. Explain the concept of intellectual property protection in conditions of competition: patent, objects of patent law, patent owner, commercial secret. Legal relations in the intellectual property market.

26. List the design stages and composition of projects: technical proposal, sketch project, technical project, working design documentation. Nomenclature of design documents.

27. Explain the concepts: technical tasks, requirements and conditions (purpose and content).

28. List the stages and stages of the life cycle of industrial products.

29. Explain the concept of investment projects. Evaluation of the effectiveness of project solutions based on the system of interrelated indicators.

30. List the stages of choosing electrical equipment in accordance with performance requirements and operating conditions.

31. Higher harmonics in current and voltage curves, their influence on electrical equipment; basic measures to ensure electromagnetic compatibility.

32. Provide indicators of the quality of electricity; harmonic composition of current and voltage; damage from higher harmonics for electrical equipment.

33. Explain the methods and devices for ensuring electromagnetic compatibility.

34. Explain the concept of electromechanical compatibility of electric motors with semiconductor converters.

35. List the main concepts and tasks of ensuring the reliability of electromechatronic systems.

36. Explain the concept of estimated calculation of the level of reliability of electrical equipment.

37. Controlled converters for low-voltage electric drive systems and their components.

38. High-voltage electric drives: scope of application; basic technical solutions in practical implementation.

39. Switching and protective equipment, chokes and filters: purpose; general and local connection schemes.

40. Methods of modernization of existing direct current drives: general approaches; example of a typical scheme.

41. Cables and wiring: basic provisions; an example of a general connection scheme. Sensors in electric drive systems.

42. Give the calculation and selection of complete electric drives and their components: the relevance of the task, the main factors and how they could be solved.

43. Determination of current and voltage harmonics in an electrical network with frequency converters.

44. Calculation and selection of electric drives of continuous operation without recuperation of braking energy into the network.

45. Electric drives of cyclic action with recuperation of braking energy into the network.

46. Rules for execution of drawings and schemes. Examples of drawings.

47. Electrical structural and functional diagrams. Implementation examples.

48. Features of implementation of principle schemes. An example of the execution of the scheme of the automation system.

49. Schemes of automated single-motor and multi-motor electric drives: execution order and examples.

50. Circuit diagrams, connection and location: execution order and examples.