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

Automation of Electrical Engineering and Mechatronic Complexes

Engineering of Electrical and Mechatronic Systems. Course Project

Course Work Program (Syllabus)

Course Requisites

Level of higher education	*Second (Master's)*
Field of knowledge	*G Engineering, Manufacturing and Construction*
Specialty	*G3 Electrical Engineering*
Educational program	*Engineering of Intelligent Electrical and Mechatronic Complexes*
Course status	*Mandatory*
Form of study	*Full-time*
Year of study, semester	*Year 1, spring semester*
Course workload	*1 ECTS credit, 30 hours*
Semester assessment / control measures	*Pass/Fail credit (3alik)*
Class schedule	*https://schedule.kpi.ua/*
Language of instruction	*Ukrainian*
Course instructor information	*Lecturer: PhD in Engineering, Associate Professor Alla Vasylivna Bosak, tel. 050-729-50-67, email: alla_koz@ukr.net*
Course platform	https://do.ipo.kpi.ua/user/index.php?id=3670

Course Program

1. Course description, goal, subject of study and learning outcomes

Goal and objectives of the course. The goal of the course "Engineering of Electrical and Mechatronic Systems. Course Project" is to familiarize students with the fundamentals of consulting and investment-construction engineering. In the process of studying the course, students learn the basics of organizing design work, become acquainted with the main electric drive schemes, and with methods of organizing construction-installation and commissioning works in the construction of electrical and mechatronic complexes.

Competencies: (GC01) Ability to search, process and analyze information from various sources; (GC02) Ability to use information and communication technologies; (GC03) Ability to apply knowledge in practical situations; (GC05) Ability to make informed decisions; (GC08) Ability to work autonomously and in a team; (FC01) Ability to apply

existing and develop new methods, methodologies, technologies and procedures for solving engineering tasks in power engineering, electrical engineering and electromechanics; (FC04) Ability to demonstrate knowledge and understanding of mathematical principles and methods necessary for use in power engineering, electrical engineering and electromechanics; (FC08) Ability to demonstrate awareness of and skill in using regulatory and legal acts, norms, rules and standards in power engineering, electrical engineering and electromechanics; (FC09) Ability to use software for computer modeling, computer-aided design, computer-aided manufacturing and computer-aided development or construction of components of power engineering, electrical and electromechanical systems; (FC12) Ability to develop tools, methods and techniques of science and technology aimed at automating existing and creating new automated and automatic technologies and production facilities; (FC13) Ability to optimize technological processes and build structural diagrams of intelligent automated control systems.

Program learning outcomes: (PLO01) Reproduce processes in power engineering, electrical engineering and electromechanical systems through computer modeling; (PLO03) Analyze processes in power engineering, electrical and electromechanical equipment and related complexes and systems; (PLO05) Master methods of mathematical and physical modeling of objects and processes in power engineering, electrical and electromechanical systems; (PLO06) Search for sources of resource support for additional education, research and innovation activities; (PLO16) Select the component base of electromechanical and mechatronic systems, complete electric and hydraulic drives, control, protection and automation tools for power supply systems of machines, installations, production sites and enterprises.

2. Prerequisites and postrequisites of the course (place in the structural-logical scheme of study for the corresponding educational program)

Interdisciplinary connections: The course “Engineering of Electrical and Mechatronic Systems. Course Project” is taught based on material from the courses “Automated Electric Drive of Machines and Installations,” “Computer Modeling of Processes in Electromechanical Systems,” “Digital and Nonlinear Electric Drive Control Systems,” “Intelligent Decision-Making Systems,” and others, which students have studied earlier or in parallel.

The knowledge and skills gained while studying the credit module “Engineering of Electrical and Mechatronic Systems. Course Project” are necessary for every specialist in this field who solves engineering tasks in the automation of electrical engineering and mechatronics, and in completing the master's thesis.

3. Learning Materials and Resources

Core literature:

1. Bosak, A. V. Engineering of Electrical and Mechatronic Systems [Electronic resource]: textbook for master's degree students in specialty 141 Power Engineering, Electrical Engineering and Electromechanics / A. V. Bosak, A. V. Toropov, L. V. Toropova; Igor Sikorsky Kyiv Polytechnic Institute. — Electronic text data (1 file: 7.43 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2024. — 251 p. https://ela.kpi.ua/handle/123456789/71628

2. Engineering of Electrical and Mechatronic Complexes. Recommendations for Completing the Course Project [Electronic resource]: study guide for master's degree students in the educational program “Engineering of Intelligent Electrical and Mechatronic Complexes,” specialty 141 Power Engineering, Electrical Engineering and Electromechanics / Igor Sikorsky Kyiv Polytechnic Institute; comp.: A. V. Bosak, A. V. Toropov, L. V. Toropova. — Electronic text data (1 file: 1.48 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2023. — 48 p. https://ela.kpi.ua/handle/123456789/62237

3. Engineering of Electrical and Mechatronic Systems [Electronic resource]: workshop: study guide for master's degree students in the educational program “Engineering of Intelligent Electrical and Mechatronic Complexes,” specialty G3 Electrical Engineering / Igor Sikorsky Kyiv Polytechnic Institute; comp.: A. V. Bosak, A. V. Toropov, L. V. Toropova. — Electronic text data (1 file: 1.46 MB). — Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2025. — 68 p. https://ela.kpi.ua/handle/123456789/74283

4. Shapoval S. L. Building Engineering: workshop: study guide / S. L. Shapoval, O. O. Paliienko, N. M. Pleshkan; ed. A. A. Mazaraki. Kyiv: KNTEU, 2018. — 231 p. Elements of Automated Electric Drive: study guide / A. P. Kalinov, V. O. Melnykov. — Kremenchuk: Shcherbatykh O.V. Publishing House, 2014. — 276 p.

5. Automation of Production Processes: textbook / I. V. Elperin, O. M. Pupena, V. M. Sidletskyi, S. M. Shved. — Kyiv: Lira-K Publishing House, 2015. — 378 p. https://sites.google.com/site/iasunuft/biblioteka/novi-vidanna

6. Shevchuk, N. A. (2019). Startup Project. Study guide for completing the “Startup Project Development” section of the master's thesis. Igor Sikorsky Kyiv Polytechnic Institute.

Supplementary literature:

7. Ukraine. Ministry of Education and Science, Lutsk National Technical University, Vakhovych, I. M., & Polishchuk, V. H. (2014). Financial Management and Financial Engineering of Business Processes: master's course: study guide in 2 volumes (2nd ed.). Lutsk: Zh. V. Hadiak.

7. Loveikin V.S., Romasevych Yu.O., Chovnyuk Yu.V. Mechatronics. Study guide. — Kyiv, 2012. — 357 p.

8. DBN A.2.2-3-2014 Composition and Content of Design Documentation for Construction. https://dbn.co.ua/load/normativy/dbn/dbn_a_2_2_3_2014/1-1-0-1168

9. DBN A.3.1-5-2016 Organization of Construction Production. https://dbn.co.ua/load/normativy/dbn/1-1-0-294

Literature with a reference link can be found online. Literature without a reference link is available in the library of Igor Sikorsky Kyiv Polytechnic Institute. Core literature [1]–[4] is mandatory reading. All other literary sources are optional and recommended for review.

Learning Content

4. Methodology for mastering the course (educational component)

Active learning strategies are applied, defined by the following methods and technologies: problem-based learning methods (research method); when completing the course project, the following methods are applied: problem-search method, work with educational and methodological literature and information resources, independent work.

Semester week	Name of the work stage
1–2	Receiving the topic and assignment. Selection and study of literature.
3–4	Market research of existing electrical and electromechanical systems on the Ukrainian market on the course project (CP) topic.
5–6	Selection of an automated control system for the selected object on the CP topic.
7–8	Calculation of operating modes and selection of electric drive components. Selection of switching electrical equipment.
9–10	Evaluation of energy performance indicators and control characteristics of the selected electromechanical system.
11–12	Selection of technical and software tools for automation systems. Synthesis of the electric drive control system using the MATLAB environment or similar software.
13	Development of an electric drive wiring diagram. Feasibility study of the design solution.
14	Preparation of graphic materials.
15	Course project defense.

Course project assignment

A single general course project topic, “Engineering of Electrical and Mechatronic Systems,” is proposed for all students. The specific mechanism/object is agreed upon with the course project supervisor. The recommended list of design objects is as follows:

1. Hoisting machines and installations of various types.
2. Conveyor installations.

3. Turbomechanisms: fans, pumps, compressors.
4. Single-bucket excavators: mechanical shovels, draglines.
5. Rotary excavators.
6. Drilling rigs.
7. Mining combines.
8. Elevator installations.
9. Civil structure objects.

Course projects may also be completed for other design objects that correspond to the training profile of graduates in specialty 141, as determined by the project supervisor at the initiative of students, thesis research supervisors, or external organizations, including stakeholders.

The initial design data are formed by the course project supervisor after selecting a specific machine or installation, taking into account the current state of the relevant industry.

Course project volume

1. The graphic part is presented in electronic and paper formats on two drawings of A1 format, prepared in accordance with DSTU.
2. The explanatory note — 20–40 pages of printed text in A4 format, prepared in accordance with DSTU.

Material that may be included in 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 object under study;
- transient process graphs by electric drive coordinates;
- transient process graphs by technological parameters;
- automation scheme of the technological process;
- electrical schematic or electrical wiring diagram;
- results of CAD system use.

Content of the explanatory note

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

5. Independent Student Work

Independent student work amounts to 30 hours.

Policy and Control

6. Course policy (educational component)

The policy of this credit module is based on the corporate policy of Igor Sikorsky Kyiv Polytechnic Institute. Igor Sikorsky Kyiv Polytechnic Institute is a free and autonomous center of education, called upon to give adequate answers to the challenges of the present, to nurture and protect the spiritual freedom of the individual, which makes them capable of acting according to their own conscience; their civic freedom, which is the basis for forming a socially responsible personality; and academic freedom and integrity, which are the main driving forces 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 project should be the acquisition of skills and abilities to build a control system for a specific technological process. The student's submission must demonstrate signs of independent completion of the assigned tasks, with no signs of repetition or plagiarism.

The higher education student must observe academic ethics and the schedule of the educational process; be balanced and attentive.

7. Types of Control and Rating System for Assessing Learning Outcomes (RSO)

Current control: Review of CP sections.

Calendar control: conducted twice per semester as monitoring of the current status of syllabus requirement completion. The condition for a positive first and second calendar control is obtaining at least 50% of the maximum possible rating at the time of the respective calendar control.

Semester control: pass/fail credit (залік).

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

The rating grade for the course project has two components. The first (starting) component characterizes the student's work on the 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 completing the course design work schedule — 5–3 points;
- currency and justification of the decisions made — 12–7 points;
- correctness of application of analysis and calculation methods — 10–6 points;
- quality of formatting, compliance with regulatory document requirements — 6–4 points;
- quality of graphic material and compliance with standard requirements — 7–4 points.

B. Course project defense component (RD):

- completeness of analysis of possible variants — 10–6 points;
- degree of command of the material — 15–9 points;
- degree of justification of the decisions made — 15–9 points;
- ability to defend one's position — 20–12 points.

2. The student's rating grade is determined as the sum of rating grades for each type of learning activity — both main (mandatory) and additional types of work under the credit module during the semester — taking into account incentive and penalty points.

After the pass/fail assessment, the rating grade (overall rating score) is determined: RD = RC + RE.

To obtain the corresponding grade for the credit module (ECTS and traditional), the student's rating grade RD is converted according to the table:

Number of points	Grade
100–95	Excellent

94–85	Very good
84–75	Good
74–65	Satisfactory
64–60	Sufficient
Less than 60	Unsatisfactory
Admission conditions not met	Not admitted

8. Additional Course Information (Educational Component)

The list of questions for semester control is provided in the syllabus appendix.

Course work program (syllabus):

Compiled by: Associate Professor, PhD in Engineering, Alla Vasylivna Bosak

Approved by the Department of Automation of Electrical Engineering and Mechatronic Complexes. Minutes №15 dated 04.06.25.

Approved by the Methodological Commission of the Educational-Scientific Institute of Energy Saving and Energy Management. Minutes №30 dated 25.06.25.

Appendix to the Course Syllabus

"Engineering of Electrical and Mechatronic Systems. Course Project"

List of Questions for Semester Control

1. Define the concepts of engineering and electromechatronics.
2. Formulate the main types of activity in the engineering of electromechatronic systems (electric drives and automation systems).
3. Give examples of possible types of engineering activity for young specialists.
4. Explain the content of the following commonly accepted terms: creation stage, creation phase, article, product, manufacturing, plant (factory), enterprise, firm, organization.
5. Give examples of systems engineering objects; the main stages of the process of product development and putting a product into production.
6. State the main functions of the customer, developer, and manufacturer.
7. Give examples of unification, aggregation, and typification techniques in systems engineering.
8. Formulate the main objects and components of electrical engineering.
9. Formulate the main provisions to be followed when executing power equipment projects; the procedure for resolving issues in design according to technical specifications.
10. What do the main regulatory documents used in electrical engineering govern?
11. Give options for creating automated electric drives; principles of building modern automated technological complexes (typical structure).
12. Explain general issues of calculation, selection, and design of automated electric drives.
13. Explain the main options for implementing modernization projects for existing equipment in automated electric drives.

14. State the main requirements for analysis and selection of the optimal electromechatronic system variant.

15. Define the concept of synthesis of electromechatronic system tools (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 modern integrated automation system tools.

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

19. Explain the content of market research.

20. Define the concept of a standard; the goals of standardization.

21. State the main concepts and provisions regarding certification.

22. Define the concept of licensing certain types of activities.

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

24. Define the concept of agreements and contracts, and their content.

25. Define the concept of intellectual property protection under competitive conditions: patent, objects of patent law, patent owner, trade secret. Legal relations in the intellectual property market.

26. State the design stages and project composition: technical proposal, preliminary design, technical design, working design documentation. Nomenclature of design documents.

27. Define the concepts of: technical specifications, requirements, and conditions (purpose and content).

28. State the stages and phases of the industrial product life cycle.

29. Define the concept of investment projects. Evaluation of design solution efficiency using a system of interrelated indicators.

30. State the stages of selecting electrical equipment according to performance requirements and operating conditions.

31. Higher harmonics in current and voltage curves, their impact on electrical equipment; main measures for ensuring electromagnetic compatibility.

32. State power quality indicators; harmonic composition of current and voltage; damage from higher harmonics to electrical equipment.

33. Explain methods and devices for ensuring electromagnetic compatibility.

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

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

36. Define the concept of an estimated calculation of the reliability level of electrical equipment.

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

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

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

40. Tools for modernizing existing DC drives: general approaches; example of a typical scheme.

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

42. State the calculation and selection of complete electric drives and their components: relevance of the task, main factors, and how they can be addressed.

43. Determination of current and voltage harmonics in the power grid with frequency converters.

44. Calculation and selection of continuous-duty electric drives without braking energy recuperation to the grid.

45. Cyclic-duty electric drives with braking energy recuperation to the grid.

46. Rules for drawings and diagrams. Examples of drawing execution.

47. Structural and functional electrical diagrams. Execution examples.

48. Features of schematic diagram execution. Example of an automation system diagram.

49. Diagrams of automated single-motor and multi-motor electric drives: execution procedure and depiction examples.

50. Connection, wiring, and layout diagrams: execution procedure and depiction examples.