CAD of ELECTROMECHANICAL SYSTEMS AND COMPLEXES

Syllabus

Details of the academic 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	*face-to-face/ remote/ mixed*
Year of training, semester	*The first autumn semester*
Scope of the discipline	*4 ECTS credits (120 hours: 36 hours - lectures, 18 hours - computer workshops, 66 hours - homework)*
Semester control/ control measures	*Exam, modular work, calculation and graphic work*
Lessons schedule	*roz.kpi.ua*
Language of teaching	*Ukrainian*
Information about head of the course / teachers	Lecturer: *Ph.D., Assoc. Listovshchyk Leonid, listovshchyk.leonid@lll.kpi.ua* Computer workshops: *Ph.D., Assoc. Listovshchyk Leonid, listovshchyk.leonid@lll.kpi.ua*
Placement of the course	*Google classroom: wimltvm*

Program of educational discipline

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

The discipline creates the basis for the study of other disciplines: Technical risks, Intelligent decision-making systems, and similar ones, which provide for the use of automated design systems for the simulation study of systems, complexes and processes in electromechanics.

***The goal** of studying the discipline is the formation of students' abilities to solve applied problems from researching existing and designing new elements and means of electromechanical systems and complexes.*

***The subject** of study of the discipline is electromechanical systems and complexes, their arrangement, features of functioning, a rational set of machines and mechanisms depending on the way they are used. The study of these issues is based on Technical Mechanics, Hydraulics and hydropneumatic drive, Physics, Related disciplines are: Engineering of electrotechnical and mechatronic systems, Reliability of electrotechnical and mechatronic systems. As a result of studying the discipline "Systems of automated design of electromechanical systems and complexes", students receive the following competencies:*

professionals:

1) ability to apply existing and develop new methods, techniques, technologies and procedures for solving engineering tasks of electric power, electrical engineering and electromechanics (K11);

2) 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 (K19);

3) ability, based on the analysis of static and dynamic loads, mode characteristics, to calculate and develop optimal equipment designs and operating modes of simple and complex electromechanical complexes using modern computer methods of mathematical modeling (K24).

and *program learning outcomes*:

1) PR01. Reproduce processes in electric power, electrotechnical and electromechanical systems during their computer simulation.

2) PR14. Master new versions or new software designed for computer modeling of objects and processes in electric power, electrotechnical and electromechanical systems.

3) PR15. Perform physical and mathematical modeling, static and dynamic analyzes of structures, mechanisms, materials, and processes at the design stage, investigate the reliability of systems, using modern computer tools.

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

The study of the discipline is based on the courses: The study of these questions is based on Technical mechanics, Hydraulics and hydropneumatic drive, Physics, Related disciplines are: Engineering of electrotechnical and mechatronic systems, Reliability of electrotechnical and mechatronic systems.

3. Content of the academic discipline

1. Topic 1.1 General information about design.
2. Topic 1.2 Use of CAD types.
3. Topic 1.3 CAD components. The main types of information in CAD
4. Topic 1.4 CAD components. Representation of objects in CAD
5. Topic 1.5 Methods of calculating the stress state of structures used in CAD.
6. Topic 1.6 Calculation of the stress-strain state of the structure using the finite element method.
7. Topic 1.7 Assessment and optimization of design technological solutions
8. Topic 1.8 Rapid prototyping and manufacturing
9. Topic 1.9 Virtual engineering

4. Educational materials and resources

Basic literature

1. INTRODUCING SOLIDWORKS. © 1995-2015, Dassault Systemes SolidWorks Corporation, a Dassault Systèmes SE company, 175 Wyman Street, Waltham, Mass. 02451 USA/ https://my.solidworks.com/solidworks/guide/SOLIDWORKS_Introduction_EN.pdf

2. Shaun Foster, David Halbstein Integrating 3D Modeling, Photogrammetry and Design. – Springer London Heidelberg ISSN 2191-5768 ISSN 2191-5776 (electronic) ISBN 978-1-4471-6328-2 ISBN 978-1-4471-6329-9 (eBook) DOI 10.1007/978-1-4471-6329-9.

3. Tickoo S. SolidWorks 2017 for Designers / S. Tickoo // CADCIM Technologies, 2017. - 2223 p.

4. Лістовщик Л.К. Основи геометричного моделювання в програмі SolidWorks. Частина 1: навчальний посібник/ Л.К. Лістовщик. – Київ: КПІ ім. Ігоря Сікорського, 2023. – 69 с. (англомовний текст)

Additional literature

5. James Floyd Kelly 3D Modeling and Printing with Tinkercad: Create and Print Your Own 3D Models. – Que Publishing 800 East 96th Street, Indianapolis, Indiana 46240 USA. 294 pages

6. Clarence T. Rivers 3D Printing: The Ultimate 3D Printing Guide. 44 pages. 2014

7. David C. Planchard SOLIDWORKS 2018 Quick Start with Video Instruction. – Published on: 2018 CSWP.

8. Theo Zizka 3D Modeling. – Cherry Lake, 2014. - 32 pages

9. Planchard C. D. Assembly Modeling with SolidWorks / C. D. Planchard, M. P. Planchard // SDC Publications, 2012. – 528 p.

10. Bethune J.D. Engineering Design and Graphics with SolidWorks 2016 / J.D. Bethune // Peachpit Press, 2016. - 784 p.

11. Onwubolu G.C. Introduction to SolidWorks: A Comprehensive Guide with Applications in 3D Printing / G.C. Onwubolu // CRC Press, 2017. - 1193 p.

12. Tickoo S. SolidWorks 2017 for Designers / S. Tickoo // CADCIM Technologies, 2017. - 2223 p.

13. Verma G. SolidWorks 2017 Black Book / G. Verma, M. Weber // CADCAMCAE Works, 2017. - 518 p.
14. Dassault System SolisWorks. http://www.solidworks.com.

Information resources

1. https://classroom.google.com/c/MTU5MjI2NDY3Nzcw?cjc=wimltvm
2. http://emoev.kpi.ua/sapr-elektromexanichnix-sitem-ta-kompleksiv/

Educational content

5. Methods of mastering an educational discipline (educational component)

The method of teaching the discipline combines visual teaching methods with explanation, including the use of distance learning technologies (Google class, zoom conferences, etc.). Teaching is conducted in the form of lectures and practical classes. When performing calculation and graphic work, the problem-search method is used.

Names of content modules and topics	Hours			
	In total	including		
		Lectures	Computer workshops	Homework
1	2	3	4	5
Lecture 1. General information about design. Basic definitions, types of design. The purpose of CAD creation. CAD used in the world.	6	2		4
Lecture 2 CAD as part of CALS - technologies. System-wide principles of CAD.	9	3	2	4
Lecture 3. Stages of CAD creation. Types of CAD support.	8	2	2	4
Lecture 4. Use of CAD, CAM and SAE in product development and production.	8	2	2	4
Lecture 5. Use of CAD in the product life cycle.	8	2	2	4
Lecture 6. CAD components. The main types of information in CAD	7	3		4
Lecture 7. Hardware. Presentation of graphic information on a computer. Basic types of graphic information.	8	3	2	3
Lecture 8. Requirements for CAD information support. Automated information systems.	7	2	2	3
Lecture 9. Data banks and information-search systems, forms of data organization.	5	2		3
Lecture 10. Methods of calculating the stress state of structures used in CAD. Methods of resistance of materials and construction mechanics.	4	1		3
Lecture 11. Numerical methods of calculating the stress state of the structure. Classification of calculations.	4	1		3

Lecture 12. Calculation of the stress-strain state of the structure using the finite element method.	*5*	*1*	*1*	*3*
Lecture 13. Basic terminology, notation and definition of the finite element method. Stages of practical implementation of the finite element method. Approximation of the original elements.	*5*	*1*	*1*	*3*
Lecture 14. Evaluation and optimization of project technological solutions. Basic technical and economic parameters.	*4*	*1*		*3*
Lecture 15. Criteria for the development of technical objects. Optimization of technical solutions. Decision making concept	*4*	*1*		*3*
Lecture 16. Rapid prototyping and manufacturing. Rapid prototyping and manufacturing processes. Longing on a solid foundation.	*5*	*1*	*1*	*3*
Lecture 17. Three-dimensional printing. Laser sintering. Lamination. Other methods of prototyping.	*5*	*1*	*1*	*3*
Lecture 18. Virtual engineering	*8*	*3*	*2*	*3*
Module work	*6*	*4*		*2*
Exam	*4*			*4*
Hours in general	*120*	*36*	*18*	*66*

Lecture classes

No	*The name of the topic of the lecture and a list of main questions*
1	*Lecture 1. General information about design. Basic definitions, types of design. The purpose of CAD creation. CAD used in the world. Recommended literature: [1, 3]*
2	*Lecture 2. CAD as part of CALS - technologies. System-wide principles of CAD. Recommended literature: [1, 10, 11]*
3	*Lecture 3. Stages of CAD creation. Types of CAD support. Recommended literature: [1, 8, 14]*
4	*Lecture 4. Use of CAD, CAM and SAE in product development and production. Recommended literature: [3]*
5	*Lecture 5. Use of CAD in the product life cycle. Recommended literature: [7, 11]*
6	*Lecture 6. CAD components. The main types of information in CAD Recommended literature: [1, 6]*
7	*Lecture 7. Hardware. Presentation of graphic information on a computer. Basic types of graphic information.*

	Recommended literature: [1, 5]
8	*Lecture 8. Requirements for CAD information support. Automated information systems.* *Recommended literature: [5]*
9	*Lecture 9. Data banks and information-search systems, forms of data organization.* *Recommended literature: [4]*
10	*Lecture 10. Methods of calculating the stress state of structures used in CAD. Methods of resistance of materials and construction mechanics.* *Recommended literature: [7,10]*
11	*Lecture 11. Numerical methods of calculating the stress state of the structure. Classification of calculations.* *Recommended literature: [10]*
12	*Lecture 12. Calculation of the stress-strain state of the structure using the finite element method.* *Recommended literature: [12]*
13	*Lecture 13. Basic terminology, notation and definition of the finite element method. Stages of practical implementation of the finite element method. Approximation of the original elements.* *Recommended literature: [13]*
14	*Lecture 14. Evaluation and optimization of project technological solutions. Basic technical and economic parameters.* *Recommended literature: [11, 13]*
15	*Lecture 16. Criteria for the development of technical objects. Optimization of technical solutions. Decision making concept* *Recommended literature: [12, 13]*
16	*Lecture 17. Rapid prototyping and manufacturing. Rapid prototyping and manufacturing processes. Longing on a solid foundation. Recommended literature: [13]*
17	*Lecture 18. Three-dimensional printing. Laser sintering. Lamination. Other methods of prototyping.* *Recommended literature: [13]*
18	*Lecture 19. Virtual engineering* *Recommended literature: [9]*

Computer workshops

The main tasks of the cycle of computer workshops are devoted to the formation of competences in the geometric design of objects of electromechanical systems and the use of CAD to determine the main characteristics of these objects.

N	*Name of the subject of the lesson and list of main questions*
1	*Creating a sketch. Creation of a 2-dimensional model of a part, with modeling of its geometric properties.* *Didactic tools: methodical instructions that allow you to form input data for execution and explain the progress of the work, video lessons.* *Recommended literature: [1 - 4]* *SRS: Completing tasks according to options on this topic.*
2	*Creating a simple 3D part. Creation of a virtual three-dimensional model of the part, with simulation of its geometric properties.* *Didactic tools: methodical instructions that allow you to form input data for execution and explain the progress of the work, video lessons.* *Recommended literature: [1 - 4]* *SRS: Completing tasks according to options on this topic.*
3	*Creating a part model by rotating the contour around an axis. Creation of a virtual three-dimensional model of the part, with simulation of its geometric properties.*

	Didactic tools: methodical instructions that allow you to form input data for execution and explain the progress of the work, video lessons. *Recommended literature: [1 - 4]* *SRS: Completing tasks according to options on this topic.*
4	*Development of a three-dimensional model of a complex part. Creation of a virtual three-dimensional model of a complex part, with modeling of its geometric properties and the use of various types of commands.* *Didactic tools: methodical instructions that allow you to form input data for execution and explain the progress of the work, video lessons.* *Recommended literature: [1 - 4]* *SRS: Completing tasks according to options on this topic.*
5	*Creating a parts assembly. Creation of a virtual three-dimensional model of the assembly of parts.* *Didactic tools: methodical instructions that allow you to form input data for execution and explain the progress of the work, video lessons.* *Recommended literature: [1 - 4]* *SRS: Completing tasks according to options on this topic.*
6	*Basics of creating drawings. Creation of documentation for details in the form of a drawing.* *Didactic tools: methodical instructions that allow you to form input data for execution and explain the progress of the work, video lessons.* *Recommended literature: [1 - 4]* *SRS: Completing tasks according to options on this topic.*

6. The students homework

The student's independent work involves:
preparation for classroom classes - 24 hours;
preparation for the modular control work - 4 hours;
implementation of computational graphic work- 14 hours.;
preparation for the exam - 24 hours

Policy and control

7. Policy of academic discipline (educational component)

The study of the educational discipline "Systems of automated design of electromechanical systems and complexes" requires the student of higher education:

- observance of educational and academic ethics;
- compliance with the schedule of the educational process;
- to be balanced, attentive in classes;
- systematically study theoretical material;
- compliance with the protection schedule of computer workshops. The applicant's answer must demonstrate signs of independent performance of the assigned task, absence of signs of repetition and plagiarism.

If the student of higher education was absent from the lecture, then he should practice this lecture at another time (with another group, at a consultation).

If the student of higher education was absent from practical classes, he should complete these classes at another time (with another group, at a consultation).

A student can receive up to 10 additional points in case of obtaining a certificate in the course "Autodesk CAD/CAM/CAE for Mechanical Engineering" on the Coursera website at the address: https://www.coursera.org/specializations/autodesk-cad-cam-cae- mechanical-engineering and the like in agreement with the teacher.

8. Types of control and rating system for evaluating learning outcomes (RSO)

The student's credit module rating consists of the points he receives for:

1) implementation and defense of 6 computer workshops;
2) execution of 1 modular control work;
3) answers during express controls at lectures;
4) answer to the exam;
5) performance of calculation work.

The system of rating points and evaluation criteria:

	timely delivery	1 transfer (within two weeks from the initial control)	2 transfers (without compliance with deadlines)
1. Performance of modular control work:			
a job completely right	12	10	8
work done with minor errors	10	8	6
work is not included	0	0	0
2. Carrying out computer workshops:			
- the task is defended with excellent mastery of the material	8	6	4
- the task was completed with excellent mastery of the material	6	4	2
- task not completed	0	0	0
3. Performance of calculation work:			
- completely correctly performed work (correctly performed at least 90%)	12	10	8
- the work was completed with minor errors (correctly completed at least 75%)	10	8	6
- work is not included	0	0	0

Calculation of the rating scale (RS).
RC(max) = 6*6 + 1*12+12 = 60 points
RC(min) = 6*3 + 1*6+6 = 30 points

According to the results of the educational work for the first 7 weeks, the maximum amount of points scored is 30 points (3 lab. practical. 1 MKR). At the first certification (8th week), the student receives "credited" if his current rating is **at least 0.5*30 = 15 points** .

According to the results of 13 weeks of training, the maximum amount of points scored should be 54 points (5 lab practicals, 1 MKR, 1 RGR). At the second certification (14th week), the student receives "credited" if his current rating is **at least 0.5*54 = 27 points** .

At the exam, students perform a written test. Each task contains 2 questions. Each question is worth 20 points.

Evaluation system of examination questions:

- "excellent", complete answer (at least 90% of the required information) - 18-20 points;
- "good", a sufficiently complete answer (at least 75% of the required information), or a complete answer with minor inaccuracies - 15-17 points;
- "satisfactory", incomplete answer (at least 60% of the required information) and minor errors - 10-14 points;
- "unsatisfactory", an unsatisfactory answer (does not meet the requirements for "satisfactory") - 0 points.

Rating scale and exam evaluation criteria (RE):

	points
- completely correct answer	40...36
- answer with minor errors	30...35
- answer with errors	29...24
- the answer is not counted	23...0

The rating scale for the discipline is R=RC+RE=60+40=100 points

Table of correspondence of rating points to grades on the university scale:

Scores	*Rating*
100-95	Perfectly
94-85	Very good
84-75	Fine
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
Admission conditions not met	Not allowed

Rs(max)=6x12+1x20+8=100 points

Rs(min)=6x12*0.5+1x20*0.5+8*0.5=50 points

According to the results of the educational work for the first 7 weeks, the maximum amount of points scored is 72 points (6 points). At the first certification (8th week), the student receives "credited" if his current rating is at least 0.5*63 = 36 points.

The maximum number of points is 100. To receive a credit from a credit module, you must have a rating of at least 50 points, as well as complete all the practicals and the module control work.

Transfer of rating points to grades on the university scale

Rating points, RD	Evaluation according to the university scale
95 ≤ RD ≤ 100	Perfectly
85 ≤ RD ≤ 94	Very good
75 ≤ RD ≤ 84	Fine
65 ≤ RD ≤ 74	Satisfactorily
60 ≤ RD ≤ 64	Enough
RD < 60	Unsatisfactorily
Non-fulfillment of conditions of admission to semester control	Not allowed

Students who, at the end of the semester, have a rating of less than 50 points perform a credit test. At the same time, points for the control work are added to the overall rating, and this rating is final. The test task consists of three questions from the lecture material.

Each question is scored as follows:

- creative approach, fully disclosed task - 9 points;
- deep disclosure of the task, minor errors - 7 points;
- reasonable disclosure, with minor errors - 5 points;
- the task is incompletely disclosed, there are errors - 3 points;
- the task is not solved - 0 points.

Additional information on the discipline (educational component)

Control questions

1. The concept of "CAD"
2. CAD as part of CALS - technologies. System-wide principles of CAD.
3. CAD creation stages.
4. Types of CAD support.
5. Use of CAD, CAM and SAE in product development and production.
6. Use of CAD in the product life cycle.
7. CAD components.
8. The main types of information in CAD.
9. Hardware.
10. Presentation of graphic information on a computer. Basic types of graphic information.
11. Requirements for CAD information support.
12. Automated information systems.
13. Data banks and information search systems, forms of data organization.
14. Methods of calculating the stress state of structures used in CAD.
15. CAD methods of resistance of materials and construction mechanics.
16. Numerical methods of calculating the stress state of the structure. Classification of calculations.
17. Calculation of the stress-strain state of the structure using the finite element method.
18. Basic terminology, notation and definition of the finite element method.
19. Stages of practical implementation of the finite element method. Approximation of the original elements.
20. Assessment and optimization of design technological solutions. Basic technical and economic parameters.
21. Criteria for the development of technical objects. Optimization of technical solutions. Decision making concept

Working program of the academic discipline (syllabus):

Compiled by Ph.D., Assoc. Listovshchik L.K

Approved by the Department of AEMK (protocol No. 17 dated 31.05.2023)

Adopted by the Methodical Council of the NN IEE (protocol No. 9 dated 06.22.2023)