Fundamentals of Computer Design and Modelling of Renewable Power Systems

Specialty
141 – Electric Power, Electrical Engineering and Electromechanics

Institute
Institute of Education and Science in Power Engineering, Electronics and Electromechanics

Educational program
Electric Power Industry

Department
Engineering Electrophysics (135)

Level of education
Bachelor's level

Course type
Special (professional)

Semester
3

Language of instruction
English

Lecturers and course developers

Mykyta Petrenko

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Ph. D., Associate Professor at the Engineering Electrophysics Department of NTU "KhPI".
Authored 6 publications in the domain of strong magnetic field calculations, computation of strong magnetic fields, electromagnetic forming and related areas. Lecturer on "Modelling of Electro-Physical and Electric Power Equipment and Processes", "High Voltage Measurements", "High Voltage Equipment", "High Voltage Pulse Equipment", etc.
More about the lecturer on the department's website

Levchenko Olena

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Candidate of Technical Sciences, Senior Lecturer at the Department of Engineering Electrophysics, NTU "KhPI".
20 years teaching experience. Main disciplines:
"Electrical Equipment in Renewable Energy Installations"
"Основи інформаційних технологій в ТВН та відновлюваній енергетиці", ect.
More about the lecturer on the department's website

General information

Summary

The "Fundamentals of Computer Design and Modelling of Renewable Power Systems" course aims to provide students with an understanding of various automated design systems used in the renewable power sector. Initially, the course offers an overview of a diverse range of such systems, detailing their types and intended purposes, including CAD (Computer-Aided Design), EDA (Electronic Design Automation), CFD (Computational Fluid Dynamics), and FEM (Finite Element Method). The latter part of the syllabus delves deeper into specific applications, focusing on the principles of 2D and 3D modeling in AutoCAD and electrical schematic design in MicroCap. Throughout this course, students will gain hands-on experience and insights into the role of computerized design in modern renewable energy system

development. No prior knowledge of these specific design tools is required, but a foundational understanding of renewable energy systems is beneficial.

Course objectives and goals

As a result of studying the course, the student should know: the tasks of automated design, the basics of technical, mathematical, software, informational, and methodological support for automated design, the principles of construction and structure of automated design systems, typical design procedures, methods of optimal design, available CAD systems for electrical engineering, their characteristics, and areas of application.

Format of classes

Lectures, workshops, laboratory classes, consultations, self-study. Final control in the form of an differential credit.

Competencies

GC 3. The ability to apply knowledge in practical situations
GC 7. Skills of using information and communication technologies.
GC 9. Ability to search, process and analyze information from various sources
PC 1. Ability to use computer-aided design (CAD), manufacturing (CAM) and engineering calculations (CAE) and related application software packages.
PC 3. Ability to use basic knowledge of general physics, higher mathematics, theoretical foundations of electrical engineering and electrical materials for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 8. Ability to use modern methods of calculations, modeling and analysis of modes of operation of electric power, electrotechnical and electromechanical equipment and design of electric and electromechanical systems.

Learning outcomes

PRT 13. Know the basics of the construction of drawings, be able to solve positional, metric and spatial problems
PRT 18. To evaluate the parameters of the electrical, electrical and electromechanical equipment and related complexes and systems work and to develop measures to increase their energy efficiency and reliability.
PRT 19. Solving professional tasks in the design, installation and operation of electric power, electrical engineering, electromechanical complexes and systems

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 32 hours, workshops - 16 hours, laboratory classes - 16 hours, self-study - 56 hours.

Course prerequisites

No special knowledge is required for this course.

Features of the course, teaching and learning methods, and technologies

Lectures employ modern multimedia tools to enhance the learning experience. Laboratory classes are structured around a mix of student preparatory self-study and collaborative team activities. Experiential learning is also an integral part of the coursework, allowing students to learn from real-world scenarios. Knowledge and skills cultivated during practical sessions are further reinforced as students tackle individual computational tasks.

Program of the course

Topics of the lectures

Topic 1. Introduction to CAD Systems

Overview of automated design, structure, execution methods, and foundational concepts of the design process. Key components supporting CAD.

Topic 2. Principles of Drafting in AutoCAD
An introduction to general principles, surveying features through a standard example.

Topic 3. AutoCAD Commands & Coordinate Input
Understanding various commands, methods of entering coordinates, and the role of different coordinate systems.

Topic 4. Drawing Information and Property Management in AutoCAD
Delving into drawing details, the object property manager, and the AutoCAD control center.

Topic 5. Essential AutoCAD Tools
Exploring layers, line types, fonts, dimension styles, external references, and object snaps.

Topic 6. 2D Drafting Techniques
Drawing 2D structures using varied reference systems and dimension-setting approaches.

Topic 7. Editing Commands in AutoCAD
Mastering essential editing commands and techniques to refine drawings.

Topic 8. 3D Solid Drawing & Visualization
Introduction to 3D modeling, using AutoCAD commands for managing 2D and 3D visuals, creating model sections, and more.

Topic 9. Introduction to MicroCap
Overview of the MicroCap environment, its relevance, and advantages in electric circuit design.

Topic 10. Basics of Schematic Entry in MicroCap
Understanding components, placing parts, wiring, and using the schematic editor.

Topic 11. Simulation Techniques in MicroCap
Introduction to DC, AC, transient, and other basic analyses. Interpreting output data and graphs.

Topic 12. Advanced Features and Components
Delving into digital models, Monte Carlo analysis, and other advanced features.

Topic 13. Debugging and Troubleshooting in MicroCap
Techniques to diagnose issues in circuits, making use of the built-in debugging tools.

Topic 14. Introduction to Renewable Energy Modeling
Understanding the importance of modeling in renewable energy systems.

Topic 15. Getting Started with System Model Advisor
Overview of the platform, understanding its interface, and its role in renewable energy modeling.

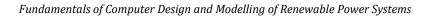### Topic 16. Advanced Modeling in System Model Advisor
In-depth exploration of renewable energy models, simulating various scenarios, and analyzing the results.

Topics of the workshops

Topic 1. Introduction to CAD Environments
Exploring and navigating the basic interface and tools of common CAD software.

Topic 2. Command Familiarization & Coordinate Practice
Practical exercises to familiarize with essential commands and coordinate systems in AutoCAD.

Topic 3. Layering & Line Techniques
Creating a complex drawing using varied layers, line types, and object snaps.

Topic 4. Refinement Techniques in AutoCAD
Tasked with editing and refining a provided complex drawing using various commands.

Topic 5. MicroCap Environment Navigation
Practical exploration of MicroCap's interface and fundamental tools.

Topic 6. Circuit Simulations with MicroCap
Conducting and interpreting basic DC and AC simulations on predefined circuits.

Topic 7. Troubleshooting in MicroCap
Given a faulty circuit, identify and rectify issues using MicroCap's debugging tools.

Topic 8. Basics of System Model Advisor
Interactive session to familiarize students with the System Model Advisor platform and interface.

Topics of the laboratory classes

Topic 1. Drafting Basics in AutoCAD
Hands-on activity drafting a simple 2D figure using AutoCAD.

Topic 2. Advanced Drawing Information Techniques
Using the object property manager and exploring the AutoCAD control center through exercises.
Topic 3. Advanced 2D Drafting
An intricate exercise focusing on advanced 2D drafting techniques and dimension settings.
Topic 4. 3D Drawing Fundamentals
Introducing basic 3D modeling with a hands-on activity to design a simple 3D structure.
Topic 5. Basic Schematic Design in MicroCap
Designing a basic electric circuit using MicroCap's schematic editor.
Topic 6. Advanced MicroCap Features Exploration
Practical application of digital models and Monte Carlo analysis in circuit design.
Topic 7. Introduction to Renewable Energy Systems
Group discussion and activity on the significance of modeling in renewable energy.
Topic 8. Advanced Energy Modeling with System Model Advisor
Guided activity on creating a renewable energy model, simulating scenarios, and result interpretation.

Self-study

The course emphasizes practical application and encourages students to engage deeply with the content through individual tasks and self-paced exploration.

Students are tasked with creating a detailed two-dimensional draft and a simple three-dimensional model using AutoCAD. This exercise not only hones drafting skills but also ensures students understand design principles and best practices.

Delve into the intricate aspects of electrical circuit design by modeling and simulating an electric circuit using MicroCap. This task is designed to deepen understanding of circuit dynamics and reinforce the concepts introduced in lectures.

Utilize the System Model Advisor to conduct a preliminary assessment of a renewable energy power station, taking into account key operational parameters, efficiency metrics, and environmental considerations.

Upon completion, students should compile their findings and insights into a comprehensive report, ensuring clarity, detail, and adherence to academic standards.

For a holistic understanding, students are encouraged to delve into additional resources. A curated list of study guides, software tutorials, and class video recordings is available, offering deeper insights into topics not extensively covered in the lectures.

Course materials and recommended reading

1. Fanebust, D. *Mastering AutoCAD and AutoCAD LT*. Indianapolis: John Wiley & Sons, 2020. - 1088 p.
2. Micro-Cap User's Manual . Spectrum Software, 2019. - 620 p.
3. SAM - System Advisor Model User Guide. U.S. Department of Energy's National Renewable Energy Laboratory (NREL), 2021. - 345 p.
4. Hambley, A.R. *Electrical Engineering: Principles & Applications*. Upper Saddle River: Prentice Hall, 2013. - 896 p.
5. James, P. *Introduction to Renewable Energy Systems*. London: Elsevier, 2019. - 700 p.
6. Cheng, Y. *AutoCAD 2021 For Beginners*. San Francisco: Independently Published, 2020. - 512 p.
7. Bir, G. *Renewable Energy System Modeling and Simulation*. Boca Raton: CRC Press, 2018. - 640 p.
8. Nelson, E. *Electrical Circuit Analysis using Micro-Cap*. New York: McGraw Hill, 2018. - 450 p.

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Assessment and grading

Criteria for assessment of student performance, and the final score structure

The final score for this course is calculated based on a combination of evaluations from module tests, practical and laboratory task achievements, and the execution of individual assignments.

1. Module Tests.
Students can earn up to 40 points from module tests. These tests evaluate the student's comprehension and knowledge retention from the lecture material.

2. Practical and Laboratory Assignments.
Engaging and participating in practical and laboratory sessions, including quizzes and tasks, can earn students up to 30 points.

3. Individual Assignments.
For the completion of individual assignments students can receive up to 30 points.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.

Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by   Date, signature   Head of the department
                                                                   Serhii MOSTOVYI

                               Date, signature   Guarantor of the educational program
                                                                   Halyna OMELIANENKO

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