Syllabus
Course Program

Technique of Strong Electric and Magnetic Fields

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
Master's level

Course type
Special (professional)

Semester
1

Language of instruction
English

Lecturers and course developers

Mykyta Petrenko

mykyta.petrenko@khpi.edu.ua
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

General information

Summary

"Technique of Strong Electric and Magnetic Fields" is a specialized course designed to explore the principles and methods of strong electric and magnetic field technologies. This course builds on foundational knowledge in theoretical electrotechnics, physics, biophysics, and the design of high-voltage impulse installations (HVII). It delves into the role of strong electric fields in various technical devices, biological cell processes, and technological applications. Key areas of focus include the structure and functionality of high-voltage impulse installations, the fundamentals of creating high-voltage power current installations, and practical approaches to calculating and experimentally verifying operational modes of HVII. Students will also be introduced to the latest developments in the field of strong electric and magnetic fields. The course combines theoretical learning with practical and laboratory work, supplementing student understanding with essential homework assignments and regular consultations for a comprehensive educational experience.

Course objectives and goals

The primary objective of this course is to familiarize students with contemporary methods in the field of strong electric and magnetic fields, essential for addressing theoretical and practical challenges in this domain. This course aims to develop proficiency in working with devices that create strong electric and magnetic fields, fostering an understanding of modern technologies based on strong impulse electric fields. Additionally, it prepares students for further study in professional cycle disciplines by encouraging independent deepening and expansion of scientific knowledge. The course is structured to ensure that students can accurately calculate and experimentally validate the operational modes of high-voltage

impulse installations. A significant goal is to acquaint students with the current trends in the development of techniques involving strong electric and magnetic fields. Through a combination of lectures, practical and laboratory works, and guided self-study, the course seeks to cultivate a thorough and practical understanding of these complex fields.

Format of classes

Lectures, workshops, consultations, self-study. Final control in the form of an examination.

Competencies

GC 3. The ability to apply knowledge in practical situations
GC 7. Skills of using information and communication technologies.
GC 8. The ability to learn and master modern knowledge.
GC 9. Ability to search, process and analyze information from various sources
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 4. Ability to use professional knowledge in the basics of electric power: electrical part of stations and substations, electrical systems and networks, relay protection and automatics of power systems and high voltage equipment for solving practical problems in the field of electric power engineering, electrical engineering and electromechanics.
PC 12. Ability to study and analyze scientific and technical information in the field of electric power engineering, electrical engineering and electromechanics.
PC 20. Receiving and using professional knowledge and understanding related to the processes of electrophysical highvoltage installations for scientific research and industrial technologies, as well as renewable energy installations.

Learning outcomes

PRT 2. Discuss professional topics
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.
PRT 40. Know and understand the processes of operation of electrophysical high-voltage installations for scientific research and industrial technologies, as well as renewable energy installations.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 48 hours, workshops - 16 hours, self-study - 56 hours.

Course prerequisites

Physics, Theoretical Foundations of Electrical Engineering p.1, Theoretical Foundations of Electrical Engineering p.2

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

Lectures employ modern multimedia tools to enhance the learning experience. Workshops 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. Strong Electric Fields in Technical Devices
Exploring the role and applications of strong electric fields in various technical devices, emphasizing their fundamental principles.
Topic 2. Strong Magnetic Fields in Biological Processes
An examination of how strong magnetic fields interact with biological processes, focusing on their effects and applications.
Topic 3. Applications of Strong Electric Fields in Technological Processes
Investigating the use of strong electric fields in modern technological processes, including their impact and efficiency.
Topic 4. Components and Elements of Technological Installations
A detailed overview of the key components and elements found in technological installations involving strong fields.
Topic 5. Arkadyev-Marx and Fitch Schemes in Impulse Voltage Generators
Studying the design and functionality of impulse voltage generators, specifically focusing on Arkadyev-Marx and Fitch schemes.
Topic 6. Spark Dischargers in Technological Installations
Understanding the role and mechanism of spark dischargers in various technological installations.
Topic 7. Impulse Voltage Transformers
Exploring the construction, operation, and applications of impulse voltage transformers in high voltage systems.
Topic 8. Generators with Shaping Devices and Magnetic Compression
Examining generators that utilize shaping devices and magnetic compression, including their design and operational principles.
Topic 9. SOS-Generators in High Voltage Applications
Discussing the principles, design, and applications of SOS-generators in high voltage and strong field contexts.
Topic 10. High Voltage Impulse Techniques for Food Sterilization
Delving into the use of high voltage impulse techniques in food sterilization, focusing on the methods and their effectiveness.
Topic 11. High Voltage Impulse Action (HVIA) Technology
A comprehensive look at HVIA technology, its principles, and the range of its applications.
Topic 12. Structure and Functioning of Broadband Electromagnetic Impulse Therapy (BEIT) Devices
Exploring the structure and functioning of BEIT devices, including their medical and therapeutic applications.
Topic 13. Ozone Generators Based on Impulse Corona Discharge
Investigating the design and use of ozone generators operating on impulse corona discharge.
Topic 14. Ozone Technologies in High Voltage Applications
Understanding the application of ozone technologies in high voltage contexts, including their advantages and challenges.
Topic 15. Advanced Techniques for Strong Electric Field Generation
Covering advanced techniques and innovations in generating strong electric fields.
Topic 16. Magnetic Field Theories and Practical Applications
An exploration of magnetic field theories and their practical applications in various fields.
Topic 17. Innovations in Strong Electric and Magnetic Field Technology
Discussing recent innovations and technological advancements in the realm of strong electric and magnetic fields.
Topic 18. Safety Measures in High Voltage and Magnetic Field Environments
Focusing on safety measures and best practices in high voltage and strong magnetic field environments.
Topic 19. Diagnostic Techniques in High Voltage Installations
Exploring various diagnostic techniques used in high voltage installations for maintenance and safety.
Topic 20. Modern Trends in High Voltage Impulse Technology
An overview of current trends and future directions in high voltage impulse technology.

Topic 21. Computational Methods for Electric and Magnetic Field Analysis
Delving into computational methods used for analyzing electric and magnetic fields.
Topic 22. Practical Considerations in Designing High Voltage Equipment
Discussing practical aspects and considerations in the design and creation of high voltage equipment.
Topic 23. Emerging Technologies in Impulse Electric Fields
Exploring emerging technologies in the field of impulse electric fields and their potential impacts.
Topic 24. Case Studies in Strong Electric and Magnetic Fields
Analyzing real-world case studies to understand the practical applications and challenges in strong electric and magnetic fields.

Topics of the workshops

Topic 1: Practical Aspects of Strong Electric Fields in Technical Devices
Hands-on exploration of strong electric fields in technical devices, focusing on practical applications and experimentation.
Topic 2: Experimentation with Strong Magnetic Fields in Biological Processes
Engaging in experiments to understand the interaction of strong magnetic fields with biological processes and their effects.
Topic 3: Application and Analysis of Strong Electric Fields in Technology
Practical application and analysis of strong electric fields in various technological processes, including hands-on exercises.
Topic 4: Design and Analysis of Components in Technological Installations
A workshop on the design and analysis of key components in technological installations involving strong fields.
Topic 5: Practical Work with Arkadyev-Marx and Fitch Scheme Generators
Engaging in practical activities with impulse voltage generators, focusing on the Arkadyev-Marx and Fitch schemes.
Topic 6: Diagnostic and Testing Techniques in High Voltage Installations
Hands-on experience with diagnostic and testing techniques specific to high voltage installations and equipment.
Topic 7: Safety and Maintenance in High Voltage and Magnetic Field Equipment
Focusing on safety protocols and maintenance practices in working with high voltage and magnetic field equipment.
Topic 8: Innovative Applications and Case Studies in Strong Electric and Magnetic Fields
Exploring innovative applications and analyzing case studies in the realm of strong electric and magnetic fields.

Topics of the laboratory classes

Self-study

In the self-study component of this course, students are tasked with applying theoretical concepts to a practical scenario involving strong electric or magnetic fields. This independent study deepens their understanding of the subject through a computational task, where they analyze and simulate real-world applications of these fields.
Additionally, students will consolidate their learning into a well-structured report, demonstrating their ability to translate theory into practice. The focus will be on clear presentation and analytical accuracy, underlining the practical implications of their studies.
To complement their learning, students are encouraged to explore supplementary materials, including selected readings and lecture recordings, broadening their understanding of the course's key topics. This approach not only reinforces classroom learning but also cultivates a comprehensive grasp of strong electric and magnetic fields in various contexts.

Course materials and recommended reading

1. Purcell, Edward M., and David J. Morin. Electricity and magnetism. Cambridge university press, 2013.

2. Jackson, John David. "Classical electrodynamics." (1999): 841-842.
3. Feynman, Richard P., Robert B. Leighton, and Matthew Sands. The Feynman lectures on physics, Vol. I: The new millennium edition: mainly mechanics, radiation, and heat. Vol. 1. Basic books, 2011.

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 exam, workshop task achievements, and the execution of individual assignments.
1. Exam.
Students can earn up to 40 points from the final exam. The exam evaluate the student's comprehension and knowledge retention from the lecture material.
2. Workshops Assignments.
Engaging and participating in workshop 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 2023	Head of the department Serhii MOSTOVYI
	Date, signature 2023	Guarantor of the educational program Halyna OMELIANENKO