Syllabus
Course Program

Theory of Electric and Magnetic Field

Specialty
141 Electric power engineering, electrical engineering and electromechanics

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

Educational program
Electric power engineering

Department
Theoretical Electrical Engineering (137)

Level of education
Bachelor's level

Course type
Mandatory

Semester
5

Language of instruction
English

Lecturers and course developers

Ivan Kostiukov

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Candidate of sciences, head of the department of theoretical electrical engineering

Author of more then 50 scientific publications, lecturer on courses "Theoretical Foundations of Electrical Engineering P.1", " Theoretical Foundations of Electrical Engineering P.2", "Theory of Electrical Circuits", "Theory of Electric and Magnetic Field
More about the lecturer on the department's website

General information

Summary

The course is intended to familiarize students with the basic processes that occur in electromagnetic field and the affect of these processes on the conditions of operation of electrical engineering equipment.

Course objectives and goals

- to provide students with fundamental knowledge about the electromagnetic field according to the level which is necessary to study and carry out research in the field, which is determined by their specialty.

Format of classes

Lectures, workshops, laboratory works, consultations. The course ends with a final exam.

Competencies

- ability to apply basic knowledge in the natural sciences and a willingness to use basic science methods to solve general engineering and professional tasks
- ability to use basic knowledge of general physics, higher mathematics, theoretical foundations of electrical engineering and electrical engineering materials to solve practical problems in the field of electrical engineering, electronics and electromechanics..

Learning outcomes

- students should be able to analyze the processes in power, electrical and electromechanical equipment and related complexes and systems
- students should improve the skills of working with modern equipment and software at performing calculations of the modes of operation of electrical, power electrical and electromechanical equipment, as well as of corresponding complexes and systems.

Student workload

The total volume of the course is 120 hours (2 ECTS credits): lectures - 32 hours, laboratory classes - 16 hours, workshops - 16 hours, self-study - 56 hours.

Course prerequisites

Within their program students are supposed to master the courses "Introduction to specialty", "Mathematics", "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

Students gain their knowledge by listening lectures with presentations and participating in discussions, workshops, laboratory classes, as well as by taking part problem-based learning.

Program of the course

Topics of the lectures

Topic 1. Introduction
Electromagnetic field as a kind of matter. Maxwell's equation. The physical essence. Electrostatic field. Basic Definitions. Charge field distributed by volume, plane, line.
Topic 2. Basic theorems and equations of electromagnetic field. Part 1
Gauss's theorem. Maxwell's third equation. Charged conductor field and dielectric sphere.
Topic 3. Basic theorems and equations of electromagnetic field. Part 2
Voltage, EMF, potential, potentiality conditions. The potential of the charge field distributed by volume, plane, line. The potential gradient. Equipotential surfaces. Poisson and Laplace equations.
Topic 4. Boundary conditions
Boundary conditions. Field on the boundary of conductor and dielectric. Electrostatic induction. Field of a two-wire line. Electric axes of conductors. Electrical capacitance.
Topic 5. Electrical capacitance
Capacitance of two-wire line, cable and flat capacitor.
Topic 6. Static and stationary electric fields
Electric field energy. Stationary electric field. Ohm's law in differential form.
Topic 7. Stationary magnetic field
Stationary magnetic field. Basic definitions. Bio-Savar law and full-current law. Maxwell's first equation.
Topic 8. Magnetic flux
The law of continuity of magnetic flux. Maxwell's fourth equation.
Topic 9.Magnetic field of a simple system of conductors.
Magnetic field of a round conductor, two-wire line, cable, toroidal coil and more. The method of mirroring.
Topic 10.Properties of magnetic field. Part 1.
Energy and forces in a magnetic field.
Topic 11. Properties of magnetic field. Part 2.
Scalar and vector magnetic potentials. Poisson and Laplace equations. Boundary conditions.
Topic 12. Properties of magnetic field. Part 3.
Quasi-stationary magnetic field. Maxwell's equation. The generalized law of electromagnetic induction. EMF and force acting on conductors of an electric machine. Motion of a conductor in a magnetic field.
Topic 13. Variable electromagnetic field.
Variable electromagnetic field. Maxwell's equation.
Topic 14. Energy of electromagnetic field.

Pointing theorem. Electromagnetic energy flow in a coaxial cable.
Topic 15. Electromagnetic wsves.
A flat electromagnetic wave in a dielectric and conductive medium. Skin effect.
Topic 16. Transition of energy in electromagnetic field
Poynting's vector. Two-wire line. Coaxial cable.

Topics of the workshops

Topic 1. Analysis of electric fields. Part 1
Calculation of the field of point charges. Calculation of an electrostatic field created by several charges.
Topic 2. Analysis of electric fields. Part 2
Calculation of the electrostatic field generated by charges distributed along the surface or along the line.
Topic 3. Analysis of electric fields. Part 3
Gauss's theorem. Calculation of a field in a spherical region. Gauss's theorem. Calculation of the field in the cylindrical region.
Topic 4. Analysis of electric fields. Part 4
Calculation of electrostatic field by Laplace equations, Maxwell's equations and Gauss's theorem.
Topic 5. Calculation of electrical capacitance in simple systems of electrodes
Capacitance of spherical and flat capacitors. Capacitance of a two-wire line. Capacitance of coaxial cable and cylindrical capacitor.
Topic 6. Energy of electric field.
Energy and forces in an electrostatic field. Stationary electric field.
Topic 7. Analysis of magnetic fields. Part 1.
Calculation of the magnetic field by the law of Bio-Savar. Full current law. Calculation of the magnetic field of a conductor with current.
Topic 8. Analysis of magnetic fields. Part 2.
Full current law. The magnetic field of a two-wire line. Coaxial cable magnetic field.

Topics of the laboratory classes

Laboratory work 1.
Study of an electromagnet.
Laboratory work 2.
Study of a coil with a ferromagnetic core.
Laboratory work 3.
Study of transformer with the magnetic core in the mode of active and capacitive load.
Laboratory work 4.
Study of stationary field in thin conductive sheet.
Laboratory work 5.
Research of a transformer with a ferromagnetic core in modes of open- and short-circuit.
Laboratory work 6.
Study of relations for the instantaneous values of alternating currents and voltages.
Laboratory work 7.
Measurement of partial capacitances in underground power transmission lines.
Laboratory work 8.
Study of coaxial cable operating modes.

Self-study

Individual assignment on the analysis of electric fields. Preparation for workshops and laboratory works

Course materials and recommended reading

1. Chew W.C. Lectures on Electromagnetic Field Theory Purdue University, 2020. - 324p.
2. Salam M.A. Electromagnetic Field Theories for Engineering Springer Science+Business Media, Singapore, 2014, 315 p.
3. Jin J.-M. Theory and Computation of Electromagnetic Fields IEEE Press + Wiley, 2010, 616 p.

4. Thide B. Electromagnetic Field Theory 2nd edition, 2009, 260 p.
5. Harita A. Lecture Notes on Electromagnetic Fields Theory. 141 p, 2019.

Assessment and grading

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

Students get their final exam mark after the complete fulfillment of their individual assignments and laboratory works

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

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