SYLLABUS OF THE ACADEMIC DISCIPLINE
«THEORETICAL FOUNDATIONS OF ELECTRICAL ENGINEERING»

Academic degree	Bachelor
Specialty	141 Electrical energetics, electrical engineering and electromechanics
Academic program	Electrical energetics, electrical engineering and electromechanics
Period of study	2-4 semesters (3-7 terms)
Total workload	9 credits ECTS (270 hours)
Classroom workload:	
lectures:	2 hours
laboratory works:	1 hour (3, 4, 6 terms), 2 hours (5 term)
Practical:	1 hour (4-7 term)
Language of study	English

Course page in E-learning platform of DniproTech:
https://do.nmu.org.ua/course/view.php?id=2632

Teaching department Electrical Engineering (EE)

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1. About this course

The fundamental discipline "Theoretical Foundations of Electrical Engineering" (TFEE) belongs to the list of normative disciplines at the educational level "bachelor", offered in the cycle of general and professional training of students within the educational program 141 "Electrical energetics, electrical engineering and electromechanics". It provides students with the formation of research professional-oriented competencies.

The TFEE discipline structurally consists of two parts: the theory of electric circuits and the theory of the electromagnetic field - these are two fundamental theories that form the basis used in all applied fields of electrical engineering, namely in power engineering, electric machines, electric drives, automatic control systems, microcircuit technique and power electronics, means

of communication and measuring devices, non-stationary processes in power supply systems and in all other electrotechnical devices.

To facilitate the mastery of the material of the discipline in the theory of electric circuits are divided into sections: stationary DC circuits; single-phase and three-phase harmonic current circuits; circuits of inharmonic currents; circles with concentrated and distributed parameters. The modes of operation of circuits are analyzed both in stationary and non-stationary modes, when there are transients that are associated with changes in the accumulated electromagnetic energy; for two-port and passive filters the frequency properties of electric circuits are investigated.

In the theory of the electromagnetic field, the following sections are distinguished: electrostatic fields in dielectric and conductive media, magnetostatic fields, which are induced by direct currents, and alternating electromagnetic fields in stationary media.

2. Aim and objectives

The aim of the course – development of future professionals' competencies in solving practical problems involving the methods of mathematics, physics and electrical engineering, as well as complex specialized tasks and practical problems related to the operation of electrical systems and networks, electrical parts of stations and substations and high voltage engineering by mastering the basics of electromagnetic field theory, methods of calculating electrical circuits and acquiring skills in their use.

Course objectives:

The main objectives of the discipline "TFEE" are

- analysis of electromagnetic phenomena;
- creation of adequate mathematical models;
- theoretical and experimental study of the features of such phenomena that reflect the essential aspects of physical processes;
- choice of methods of analysis of characteristic of electromagnetic processes.

3. Learning outcomes

Disciplinary learning outcomes:

- know the methods for calculating DC electrical circuits and be able to use them to solve specialized problems;
- know the methods for calculating single-phase alternating current electrical circuits and be able to use them to solve specialized problems;
- know the methods of calculating three-phase alternating current electrical circuits and be able to use them to solve specialized problems and practical problems;
- know the methods of analysis and calculation of nonlinear electrical circuits and be able to use them to solve specialized problems and practical problems;
- know the fundamentals of the theory of four-pole circuits, passive filters and circuits with distributed parameters and be able to use them to solve specialized tasks and practical problems;
- know the fundamentals of electromagnetic field theory and be able to use them to solve specialized tasks and practical problems;
- master the methods of analyzing transients in electrical circuits and be able to use them to solve specialized problems and practical problems.

4. Course program

LECTURES
1. Linear DC circuits at steady state mode
1.1. Introduction. Current, voltage, power, resistance, conductivity
1.2. Voltage and current sources
1.3. Dropping voltage across the section of the circle. Ohm's law.
1.4. Power balance in an electric DC circuit.
1.5. Methods for calculating resistive circuits.
1.6. Conclusions
2. Linear circuits of single-phase current at steady state mode
2.1. Harmonic oscillations
2.2. Instant, average and rms value of harmonic voltages and currents
2.3. Representation of harmonic functions by vectors and complex numbers
2.4. Harmonic oscillations in elementary resistive, inductive and capacitive circuits
2.5. Harmonic oscillations in series-connected RLC elements
2.6. Harmonic oscillations in parallel-connected RLC elements
2.7. Phase calculation method for branched circles with harmonic oscillations
2.8. Power balance in an AC circuit.
2.9. Resonance in AC electrical circuits.
2.10. Conclusions
3. Magnetically coupled linear circuits of single-phase current in a steady-state mode
3.1. The phenomenon of mutual inductance. Coefficient of mutual induction.
3.2. Series connection of magnetically coupled coils
3.4. Parallel connection of magnetically coupled coils
3.5. Methods for calculating circles with magnetically coupled elements
3.6. Power balance in circles with magnetically coupled elements.
3.7. Conclusions
4. Linear circuits of three-phase current in constant mode
4.1. Multiphase electric circuits
4.2. Wye connection in three-phase circuits
4.3. Delta connection in three-phase circuits
4.4. Power balance in three-phase circuits. Power measurement of a three-phase circuit.
4.5. Method of symmetrical components
4.6. Conclusions
5. Linear circuits of polyharmonic current in steady state mode
5.1. Representation of polyharmonic currents and voltages by Fourier series
5.2. Calculation of circuits in the presence of polyharmonic currents and voltages sources
5.3. The rms value of polyharmonic currents and voltages
5.4. Power balance in circuits with polyharmonic currents and voltages
5.5. Resonance in electrical circuits with polyharmonic currents and voltages
5.6. Polyharmonic currents and voltages in three-phase circuits
5.7. Conclusions
6. Classical and operator methods of analysis of transients in linear circles with lumped parameters
6.1. The emergence of transients
6.2. Laws of switching in electric circuits

6.3. Transients, forced and natural processes in electrical circuits
6.4. Definition of the characteristic equation
6.5. Definition of integration constants
6.6. The order of calculation by the classical method of transients
6.6.1. Analysis of transients in linear circuits by the classical method with one and two energy storage devices
6.7. Analysis of transients in linear circles by the operator method
6.7.1. Conversion originals to images
6.7.2. Laws of electric circuits in operator form
6.7.2. Calculation of operator equvalent circuits
6.7.3. The order of calculation by the operator method of transients
6.7.4. Analysis of transients in linear circles by the operator method
6.7.5. Conversion images to originals
6.8. Calculation of the response of the circle to the signal of any shape
6.8.1. Using the Duhamel integral when connecting a circuit to a signal of arbitrary shape
6.9. Conclusions
7. Nonlinear DC circuits in steady state mode
7.1. Graphical representation of volt-ampere characteristics of nonlinear elements
7.2. Static and dynamic resistances of nonlinear elements
7.3. Calculation of nonlinear circuits with series, parallel and mixed connection of elements
7.4. Calculation of electrical circuits by the method of equivalent generator
7.5. Calculation of electrical circuits by the method of two nodes
7.6. Conclusions
8. Nonlinear AC circuit in steady state mode
8.1. Features of periodic processes in nonlinear circuits with inertial elements
8.2. Coil with a steel cell powered by a harmonic voltage source. Equivalent harmonic currents and voltages
8.3. Equivalent circuit and vector diagram of coils with steel core
8.4. Ferroresonance phenomenon
8.5. Ferroresonant voltage stabilizers, magnetic power amplifiers, harmonic ferromagnetic separators
8.6. Features of the analysis of circuits with semiconductor diodes
8.7. Conclusions
9. Analysis methods of transients in nonlinear circuits
9.1. Stability of operation mode of nonlinear circles
9.2 Method of piecewise-linear approximation of the self-oscillating circle
9.3. Methods for calculating transients in a coil with a steel core
9.4. Representation of transients in the phase plane
9.5. Conclusions
10. Fundamentals of the theory of two-port circuits
10.1. The equation of two-port circuits
10.2. Modes of open and short circuit of two-port circuits
10.3. Determining the parameters of two-port circuits
10.4. Matched impedance and propagation coefficient of symmetric two-port circuits
10.5. Two-port circuits transfer functions and feedback
10.6. Conclusions

11. Passive reactive filters
11.1 Basic properties of reactive filters
11.2. Frequency characteristics of filters
11.3. Low frequency filters
11.4. High frequency filters
11.5. Band pass filters
11.6. Band stop filters
11.7. Conclusions
12. Circles with distributed parameters
12.1. Lumped and distributed parameters of electrical circuits
12.2. Equation of a homogeneous line
12.3. Solving homogeneous line equations in stationary modes
12.4. Running and standing waves
12.4. Voltage and current distribution along a long line
12.5. Transients in homogeneous lines
12.6. Conclusions
13. Electrostatic field in a dielectric medium
13.1. Vortex-free nature of the electrostatic field
13.2. Gauss's theorem
13.3. Poisson and Laplace equations
13.4. Boundary conditions
13.5. Electrostatic field energy density
13.6. Elementary electrostatic fields
13.7. Conclusions
14. The magnetic field of direct current
14.1. The law of total current. Scalar magnetic potential
14.1. Vector magnetic potential
14.2. Boundary conditions
14.3. Magnetic field energy density
14.4. Elementary magnetic fields
14.5. Conclusions
15. Alternating electromagnetic field in a stationary medium
15.1. Displacement current
15.2. Maxwell's equation
15.3. Poiting's theorem
15.4. Flat waves in a homogeneous dielectric
15.5. Conclusions
LABORATORY CLASSES
1. Linear DC circuits in steady state mode
Research of a branched circle by the method of transformations
Power transmission from active to passive one-port circuits
2. Linear circuits of single-phase current in steady state mode
Series connection of elements
Parallel connection of elements
Series resonance
Parallel resonance

3. Magnetically coupled linear circuits of single-phase current in steady state mode
Series and parallel connection of magnetically coupled coils
4. Linear circuits of three-phase current in steady state mode
Symmetrical three-phase source and symmetrical load connected in a symmetrical and asymmetrical wye
Symmetrical three-phase source and symmetrical load connected in a symmetrical and asymmetrical delta
Asymmetric three-phase source and symmetrical load connected to a symmetrical wye
5. Linear circuits of polyharmonic current in steady state mode
Polyharmonic currents and voltages in single-phase circuits
Polyharmonic currents and voltages in three-phase circuits
6. Classical and operator methods of analysis of transients in linear circles with lumped parameters
Transients in the resistive-inductive circuit
Transients in the resistive-capacitive circuit
The discharge of the capacitor on the resistive-inductive circuit
7. Nonlinear DC circuits in steady state mode
Branched nonlinear DC circuit
8. Nonlinear alternating current circuits in steady state mode
Inductor with steel core on alternating current
9. Methods of analysis of transients in nonlinear circles
Self-oscillation in a nonlinear circle
10. Fundamentals of the theory of two-port circuits
Parameters of an asymmetric two-port circuits
12. Circles with distributed parameters
Homogeneous long line
13. Electrostatic field in a dielectric medium
Electrostatic field modeling
14. The magnetic field of direct current
Magnetic field around a current-carrying conductor
PRACTICAL TRAINING
1. Linear DC circuits in steady state mode
2. Linear circuits of single-phase current in steady state mode
3. Magnetically coupled linear circuits of single-phase current in steady state mode
4. Linear circuits of three-phase current in steady state mode
5. Linear circuits of polyharmonic current in steady state mode
6. Classical and operator methods of analysis of transients in linear circles
7. Nonlinear DC circuits in steady state mode
8. Nonlinear alternating current circuits in steady state mode
9. Fundamentals of the theory of two-port circuits
10. Passive reactive filters
11. Circles with distributed parameters in steady state modes

5. Technical equipment and/or software

№	Work title	Tools, equipment and software

works (code)		used in the work
TFEE-1	Linear DC circuits in steady state mode. Research of a branched circle by the method of transformations	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-2	Linear DC circuits in steady state mode. Power transmission from active to passive two-port circuits	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-3	Linear circuits of single-phase AC in steady state mode. Series connection of elements, voltage resonance.	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-4	Linear circuits of single-phase AC in steady state mode. Parallel connection of elements, resonance of currents.	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-5	Linear circuits of single-phase AC in steady state mode. Magnetically coupled linear circuits of single-phase current in steady state mode.	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-6	Linear circuits of three-phase current AC in steady state mode. Symmetrical three-phase source and symmetrical load connected in a symmetrical and asymmetrical wye	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-7	Linear circuits of three-phase current AC in steady state mode. Symmetrical three-phase source and symmetrical load connected in a symmetrical and asymmetrical delta	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-8	Linear circuits of three-phase current AC in steady state mode. Asymmetrical three-phase source and symmetrical load connected in symmetrical wye.	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-9	Linear circuits of polyharmonic current in steady state. Polyharmonic currents and voltages in single-phase circuits.	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-10	Linear circuits polyharmonic Polyharmonic currents and voltages in three-phase circuits in steady state.	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-11	Classical and operator methods of analysis of transients in linear circuits with concentrated parameters. Transients in the resistive-inductive circuit	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-12	Classical and operator methods of analysis of transients in linear circles with concentrated parameters. Transients in the resistive-capacitive circuit.	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-13	Classical and operator methods of analysis of transients in linear circles with concentrated parameters. The discharge of the capacitor on the resistive-inductive circuit	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-	Branched nonlinear DC circuit.	Study-research laboratory stand

14		УИЛС-2, multimeter, oscilloscope
TFEE-15	Inductance coil with steel core for alternating current	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-16	Self-oscillation in a nonlinear circle	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-17	Parameters of an asymmetric quadrupole	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-18	Homogeneous long line	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-19	Electrostatic field modeling	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope
TFEE-20	Magnetic field around a current-carrying conductor	Study-research laboratory stand УИЛС-2, multimeter, oscilloscope

6. Evaluation system and requirements

6.1. The academic achievements of higher education applicants based on the results of the completion of the course will be evaluated on the scale below:

Rating	**Institutional**
90 – 100	Excellent
74 – 89	Good
60 – 73	Satisfactory
0 – 59	Fail

The general criteria for achieving the learning outcomes correspond to the descriptions of the 6th qualification level of the NQF.

6.2. Applicants for higher education can receive **a final grade** in this course based on the formative assessment of their knowledge, provided that the total number of points gained from the formative testing and the independent work will be at least 60 points.

Maximum rating:

The theoretical part	The practical part		Bonus	**Total**
	in time turn-ins	late turn-ins		
66	30	20	4	**100**

Laboratory works are accepted according to the control questions for each of the works.

The theoretical part is assessed by the results of a survey of students according to the plan of the theoretical course and independent work.

Practical works are accepted on control questions to each of work.

6.3. Criteria for evaluating the final work:

If the higher education applicant has scored less than 60 points and / or seeks to improve the grade, a summative assessment is carried out in a form of a complex control work, which contains tasks that cover key learning outcomes. Final control takes the form of written work. The ticket contains 6 questions, of which 5 - tests, 1 task. 5 test tasks with four answer options, 1 correct answer is evaluated in 3 points. The test is conducted using MicrosoftFormsOffice 365 technology.

Correctly solved problem is estimated at 5 points, and:

– 5 points - compliance with the standard, with units of measurement;
– **4 points** - compliance with the standard, without units of measurement or errors in calculations.
– 3 points - minor errors in formulas, without units of measurement.
– **2 points** - there are significant errors in the decision
– **1 poin**t - the given formulas do not completely correspond to the standard.
– 0 points - no solution is given.

6.4. Criteria for evaluating practical work:

From each practical work the applicant receives 5 questions from the list of control questions. The number of correct answers determines the number of points obtained.

7. Course policy

7.1. Policy on academic integrity. The academic integrity of higher education applicants is an important condition for mastering the learning outcomes of the course and obtaining satisfactory grades in formative and summative assessments. Academic integrity is based on the condemnation of the practices of cheating (writing with the involvement of external sources of information other than those authorized for use), plagiarism (reproduction of published texts of other authors without proper attribution), fabrication (inventing data or facts used in the educational process). The policy on academic integrity is regulated by the Regulation on system of prevention and detection of plagiarism at the Dnipro University of Technology (https://www.nmu.org.ua/ua/content/activity/us_documents.pdf)

If a higher education applicant violates academic integrity (cheating, plagiarism, fabrication), the assignment is graded unsatisfactory and must be repeated. In this case, the instructor reserves the right to change the topic of the assignment.

7.2. Communication policy. Applicants for higher education must have an activated corporate university email.

All written questions to the instructors regarding the course should be sent to the university email.

7.3. Policy on retakes. Assignments that are submitted late without valid reasons will be evaluated at a lower grade. Retakes of the summative assessment are allowed with the permission of the dean's office if there are valid reasons (e.g., sick leave).

7.4. Class attendance. Attendance at classes is mandatory for full-time applicants for higher education. Valid reasons for absence from classes are illness, participation in university events, and academic mobility, which must be confirmed by documents. A higher education applicant must notify the instructor either personally or through the leader of the academic group about the absence from class and the reasons for the absence.

For objective reasons (e.g. international mobility), studies may take place online with the consent of the course instructor.

7.5 Evaluation appeal policy. If a higher education applicant does not agree with the evaluation of his/her knowledge, he/she may appeal the grade assigned by the instructor in a prescribed manner.

7.6. Bonuses. Upon completion of the course and before the start of the examination period, the applicant for higher education will be asked to anonymously fill out electronic questionnaires (Microsoft Forms Office 365), which will be sent to your university mailboxes. Filling out the questionnaires is an important component of your learning activity, which will allow us to evaluate the effectiveness of the applied teaching methods and consider your suggestions for improving the content of the course "Theoretical Foundations of Electrical Engineering". For participation in the survey and/or in scientific work, and conferences, the applicant for higher education receives **4 points**.

8 Recommended sources of information

1 Khilov V.S. Theoretical fundamentals of electric engineering. Підручник. / В. С. Хілов – Д., 2018. – 467 с.

2 Теоретичні основи електротехніки. Електричні кола: навч. посібник / В.С. Маляр. – Львів: Видавництво Львівської політехніки, 2012. – 312 с.

3 Теоретичні основи електротехніки. Усталені режими лінійних електричних кіл із зосередженими та розподіленими параметрами : підручник / Ю. О. Карпов, С. Ш. Кацив, В. В. Кухарчук, Ю. Г. Ведміцький ; під ред. проф. Ю. О. Карпова – Вінниця : ВНТУ, 2011. – 377 с.

4 Теоретичні основи електротехніки: Частина 1. Електричні кола постійного та змінного струму. Чотириполюсники [Електронний ресурс]: навч. посіб. для студ. спеціальності 141 «Електроенергетика, електротехніка та електромеханіка»/ КПІ ім. Ігоря Сікорського; уклад.: Ю. В. Перетятко, А. А. Щерба– Електронні текстові дані (1 файл: 21.7 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2021. – 115 с

5 Овчаров В.В. Теоретичні основи електротехніки, частина 1. Мелітополь : Видавничо-поліграфічний центр «Люкс», 2007. 389 с.

6 Collection of methodical materials for laboratory work on discipline «Theoretical fundamentals of electrical engineering» for full-time students' majoring in 141 – Electric Power, Electrical Engineering and Electromechanical. Part 1 "Fundamentals of the theory of DC circuits"; "Fundamentals of the theory of harmonic single-phase currents" / V.S.Khilov; Dnipro University of Technology – D.: DniproTech, 2021. – 35 p.

7 Collection of methodical materials for laboratory work on discipline «Theoretical fundamentals of electrical engineering» for full-time students' majoring in 141 – Electric Power, Electrical Engineering and Electromechanical. Part 1 "Three-phase circuits", "Polyharmonic currents and voltages in single-phase and three-phase circuits", "Transients in linear electric circuits" / V.S.Khilov; Dnipro University of Technology – D.: DniproTech, 2021. – 52 p.

8 Collection of methodical materials for laboratory work on discipline «Theoretical fundamentals of electrical engineering» for full-time students' majoring in 141 – Electric Power, Electrical Engineering and Electromechanical. Part 3 "Nonlinear electric circuits of direct and alternating currents", "Magnetic circuits", "Transients in circuits with nonlinear elements" / V.S.Khilov; Dnipro University of Technology – D.: DniproTech, 2021. – 30 p.

9 Collection of methodical materials for to independent and practical works on discipline «Theoretical fundamentals of electrical engineering» for full-time students' majoring in 141 – Electric Power, Electrical Engineering and Electromechanical. Part 1 «Theory fundamentals of dc

and single-phase harmonic ac circuits» / V.S.Khilov; Dnipro University of Technology – D.: DniproTech, 2021. – 44 p.

10 Collection of methodical materials for to independent and practical works on discipline «Theoretical fundamentals of electrical engineering» for full-time students' majoring in 141 – Electric Power, Electrical Engineering and Electromechanical. Part 2 «Three–phase circuits, Polyharmonical voltages and currents in circuit, Transient analisis of a linear circuits» / V.S.Khilov; Dnipro University of Technology – D.: DniproTech, 2021. – 99 p.

11 Collection of methodical materials for to independent and practical works on discipline «Theoretical fundamentals of electrical engineering» for full-time students' majoring in 141 – Electric Power, Electrical Engineering and Electromechanical. Part 3 « DC and AC nonnlinear circuits, Magnetic circuits, Transients into circuits with nonlinear elements» / V.S.Khilov; Dnipro University of Technology – D.: DniproTech, 2021. – 35 p.