National Technical University of Ukraine
"Igor Sikorsky Kyiv Polytechnic Institute"

Department of
biomedical engineering

ELECTRICAL ENGINEERING AND ELECTRONICS

Working program of basic discipline (Syllabus)

Requisites of the Course	
Level of higher education	***First cycle of higher education (Bachelor's degree)***
Branch of knowledge	*16 «Chemical and bioengineering»*
Specialty	*163 «Biomedical engineering»*
Educational program	*Medical Engineering*
Discipline status	*Mandatory discipline*
Form of study	*full-time*
Year of preparation, semester	*2nd year, spring semester*
The scope of discipline	*5,5 credits (ECTS).* *Time allotment - 165 hours, including 82 hours of classroom work, and 83 hours of self-study*
Semester control / Control measures	*Exam / Modular Control Work, Calculation and Graphic Work*
Lessons schedule	*3 classes per week by the timetable http://rozklad.kpi.ua/*
Language of Instruction	*English*
Information about course leader / teachers	Lecturer: *Doctor of Engineering Sciences, Associate Professor, Maksym Shcherba, e-mail: m.shcherba@gmail.com, telegram: @m_shcherba* Teacher of practical work: Teacher of laboratory worki: *www.toe.fea.kpi.ua*

Outline of the Course

1. Course description, goals, objectives, and learning outcomes

The curriculum of the discipline "Electrical Engineering and Electronics" is compiled in accordance with the educational and professional bachelor's program in the field of knowledge 16 "Chemical and Bioengineering" in the specialty 163 "Biomedical Engineering".

The goal of the discipline is to form students' ability to use the basic laws of electrical engineering and electronics to solve professional problems in the field of biomedical engineering, to study the course of electromagnetic processes in electrical circuits and specific devices.

The object of the discipline – the laws of electric circuits theory, typical mathematical methods of analysis of steady-state electric circuits of direct current, alternating sinusoidal current in single-phase and three-phase networks, typical methods of analysis of transients in linear electric circuits.

As a result of studying the discipline the student must:

Know: conventional circuit symbols of elements and their characteristics; methods of analysis of steady processes in linear electric circuits of direct and sinusoidal currents with concentrated parameters; energy processes in electrical circuits; methods of analysis of resonant modes in linear electric circuits; methods of analysis of transients in linear circles.

Be able to: form mathematical models of electrical circuits; to form schemes of an equivalent circuit; calculate the steady-state and transient modes in a linear electric circuit in which there are sources of direct or sinusoidal electromotive force.

Gain experience: practical application of methods of mathematical modeling and calculation of processes in technical devices, the principle of operation of which is based on the use of electromagnetic phenomena; making experimental research and summarizing their results; competent use of switching equipment and electrical measuring equipment for various purposes; independent work with educational, educational-methodical and reference literature in the field of electrical engineering and electronics and related disciplines.

2. Prerequisites and post-requisites of the course (the place of the course in the scheme of studies in accordance with curriculum)

To successfully master the discipline, the student must have a theoretical base of disciplines "Higher Mathematics", "Physics". The discipline "Electrical Engineering and Electronics" precedes the study of disciplines "Theory of automatic control", "Design of automatic control systems", "Digital circuitry", "Biomedical devices, apparatus and complexes".

3. Content of the course

SECTION 1. *Linear DC circuits.*

Topic 1.1. *Basic concepts and laws of the electric circuit.*

Topic 1.2. *Methods of calculating the electrical circuit.*

SECTION 2. *Linear electric circuits of single-phase sinusoidal current.*

Topic 2.1. *The main properties of a sinusoidal current circuit and its calculation.*

Topic 2.2. *Resonant phenomena and frequency characteristics.*

SECTION 3. *Three-phase electrical circuits.*

Topic 3.1. *Analysis of three-phase electric circuits*

SECTION 4. *Transients in linear electric circuits.*

Topic 4.1. *The classical method of calculating transients*

4. Coursebooks and teaching resources

1. Yuliia Peretyatko, Liudmyla Spinul, Maksym Shcherba Theoretical fundamentals of electrical engineering. Single phase AC circuits [Electronic resource]: tutorial for students doing Bachelor's degree programmes in speciality “141 Electric Power Engineering, Electrical Engineering and Electromechanics” Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2020. 62 p.
https://ela.kpi.ua/handle/123456789/42070

2. Ju. V. Peretyatko, L. Y. Spinul Theoretical fundamentals of electrical engineering. Linear network theory [Electronic resource]: tutorial for bachelor's degree programs for specialty "141 Electricity, electrical engineering and electromechanics" Kyiv: Igor Sikorsky Kiev Polytechnic Institute, 2019. 44 p.
https://ela.kpi.ua/handle/123456789/42066

3. Yuliia Peretyatko, Liudmyla Spinul, Maksym Shcherba Theoretical fundamentals of electrical engineering. Part 1 [Electronic resource]: tutorial for students doing Bachelor’s degree programmes in speciality “141 Electric Power Engineering, Electrical Engineering and Electromechanics” Kyiv: Igor Sikorsky Kyiv Polytechnic Institute, 2021. 137 p. Title from the screen.
https://ela.kpi.ua/handle/123456789/42069

4. Nilsson, J. W., & Riedel, S. A. Electric circuits. Tenth edition. Pearson Education Limited. 2020.
https://ktuee.files.wordpress.com/2019/11/electric-circuits-by-james-w.-nilsson-susan-riedel-10th-edition.pdf

Educational content

5. Methodology

Lectures

№	*The title of the lecture topic and a list of key issues (list of teaching tools, links to information sources)*
Section 1 ***LINEAR ELECTRICAL DC CIRCUITS***	
1	Electric circuit, its elements. Volt-ampere characteristic (I – V characteristics) of elements. Linear and nonlinear elements. Energy sources: voltage source, current source. Equivalent circuits and I – V characteristics of energy sources. Conditions of equivalence of equivalent circuits. **The structure of the electrical circuit and the basic laws.** Topological elements of an electric circuit.
2	**Basic laws of the electrical circuit.** Ohm's law: for the conductor section, for the EMF branch, for a closed circuit. Kirchhoff's first and second laws. Determination of a voltage in the part of a circuit. **Methods of calculation of complex electric circuits.** The method of Kirchhoff's equations. Power balance in the electrical circuit.
3	**Methods of calculating complex electrical circuits.** Mesh current method. Own and intermesh resistances. Nodal voltage method. Own and internodal conductivities.
4	**Equivalent transformations in electric circuits.** Transformation of passive branches of an electric circuit: series and parallel connection; star – triangle (wye – delta) transformation of resistances. Transformation of a circuit parts with energy sources: series connection with EMF sources, parallel connection with current sources and EMF.
5	**Active and passive two-poles (terminals).** Definition two-poles (terminals). The theorem of an active two-pole. The method of an active two-pole (equivalent generator method) and its using to calculate the branch current. Transfer of energy from the active two-pole to the passive. Maximum power transmission condition.
Section 2 ***LINEAR SINGLE-PHASE SINUOSIDE CURRENT ELECTRICAL CIRCUITS***	
6	**Basic properties of sinusoidal current. Time and vector diagrams.** Instantaneous current and voltage values, phase of oscillations, initial phase, phase shift angle. Time diagrams. Effective (rms) current and voltage values. Representation of sinusoidal currents and voltages by rotating vectors and complex functions. Vector diagrams.
7	**Features of physical processes in an alternating current (AC) circuit.** The relationship between voltages and currents on the elements of the AC circuit. Equivalent scheme of an AC circuit. Kirchhoff's laws for an alternating current circuit.
8	**Voltages and powers of *R*, *L*, *C* elements at sinusoidal current. Active and reactive resistances.** Element *R* at sinusoidal current: instantaneous functions of current, voltage, power. Active power, active resistance. Element *L* at sinusoidal current: instantaneous functions of current, voltage, power. Reactive resistance of inductance. Element *C* for sinusoidal current: instantaneous functions of current, voltage, power. Reactive resistance of the capacitance.
9	**Serial and parallel connection of *R*, *L*, *C* elements at sinusoidal current.** Voltage equation for series connection. Active and reactive voltage, active and reactive resistance. Vector diagram of a serial connection. Triangles of voltages and currents. Equation for currents for parallel connection. Active and reactive currents, active and reactive conductivity. Complex conductivity. Vector diagram of currents for parallel connection. Triangles of currents and conductivities. **Calculation of a complex circuit by a symbolic (complex) method.**

10	**Power of a sinusoidal current circuit.** Active, reactive and full power of a circuit. The relationship between power and circuit parameters. Complex power. Power balance.
11	**Resonance in a series oscillatory circuit.** Conditions of resonance. Vector diagram of the resonant state. Tuning and frequency characteristics of the serial circuit. Energy processes at series resonance. **Resonance in a parallel oscillating circuit with losses.** Conditions of resonance. Possibilities of achieving resonance when changing the frequency. The relationship between currents and circuit parameters at parallel resonance. Vector diagram of the resonant state.
12	**Basic definitions and classification of multiphase systems. Calculation of a symmetric three-phase circuit.** Basic definitions of multiphase systems. Time and vector EMF diagrams and the principle of operation of a three-phase synchronous generator. Calculation scheme for the phase of a symmetrical 3-phase circuit. Determination of currents and voltages in the calculation scheme and in all phases of the circuit. Example of calculation. Combined vector diagram of currents and voltages of a symmetrical 3-phase circuit.
13	**Calculation of a nonsymmetric three-phase circuit.** Calculation of a nonsymmetric three-phase circuit when connecting consumers with a "star" and a "triangle" (“wye” and “delta”). Examples of calculations. Vector diagram of currents and voltages.
14	**Transients in a linear electric circuit.** Causes of transients. Laws of switching. Initial conditions. The procedure for calculating the transient process by the classical method. Transients in *RL* circuit: characteristic of free mode, switching of a circuit on a constant EMF. Transients in the *RC* circuit: the characteristic of the free mode, the switching of a circuit on a constant EMF.

Practical Classes

№	*Summary of practical classes*
Section 1 **LINEAR ELECTRICAL DC CIRCUITS.**	
1.	**Simple electrical circuits. Transformation in an electric circuit. Ohm's law, Kirchhoff's laws.** Series, parallel and mixed connection of resistors. Voltage and current sources. Using Ohm's law for a branched circle with one EMF source.
2.	**The method of Kirchhoff's laws. Power balance of the electric circuit.** The algorithm of an electric circuit calculation using Kirchhoff's laws. Calculation of power balance in an electric circuit.
3	**Meth-current method. Power balance of an electric circuit.** The algorithm of an electric circuit calculation by the meth-current method. Determination of circuit resistances and circuit EMF. Determination of branch currents through loop currents. Calculation of power balance in an electric circuit.
4	**Nodal voltages method. Power balance of the electric circuit.** The algorithm of an electric circuit calculation by the nodal potentials method. Selection of the reference (base node). Determination of nodal conductivities and nodal currents. Determination of branch currents. Calculation of power balance in an electric circuit.
5	**Superposition method. Power balance of the electric circuit.** The algorithm of an electric circuit calculation by the method of superposition of energy sources. Determination of input and mutual conductivities. Drawing up a balance of capacities of an electric circuit. Calculation of power balance in an electric circuit.

6	**Active two-poles (terminal) method (equivalent generator).** The algorithm of an electric circuit calculation by the method of active two-pole. Determination of equivalent parameters of the two-pole. Transmission of maximum power from the active two-pole to the passive.
7	**Modular control work (part 1):** calculation of a complex DC circuit.
Section 2 **LINEAR ELECTRICAL CIRCUITS OF SINGLE PHASE SINUOSIDE CURRENT.**	
8	**Calculation of circuits of sinusoidal current for series and parallel connection of elements.** Using Ohm's law and Kirchhoff's first law in a complex form. Instantaneous values of currents and voltages, vector diagrams.
9	**Calculation of the sinusoidal current of the mixed connection. Part 1.** Serial-parallel connection of elements and its calculation by a symbolic method. Determination of complex equivalent resistances of mixed connection, calculation of complex currents and voltages of branches. Vector diagram of currents and voltages. Calculation of power balance in an electric circuit.
10	**Calculation of the sinusoidal current of a mixed connection. Part 2.** Serial-parallel connection of elements and its calculation by a symbolic method. Determination of complex equivalent resistances of mixed connection, calculation of complex currents and voltages of branches. Vector diagram of currents and voltages. Calculation of power balance in an electric circuit.
11	**Calculation of a complex sinusoidal current circuit.** Application of methods of mesh-currents and nodal voltages for calculation of a complex circuit of sinusoidal current. Calculation of power balance in an electric circuit.
12	**Resonance of voltages.** Resonant phenomena in a series circuit. Determination of series resonance condition parameters.
13	**Resonance of currents.** Resonant phenomena in a parallel circuit. Determination of parallel resonance condition parameters.
14	**Modular control work (part 2):** calculation of the sinusoidal current circuit by the symbolic method.

Laboratory works

№	Summary of laboratory works
Section 1 **LINEAR ELECTRICAL DC CIRCUITS.**	
1	Simulation of a real DC voltage source.
2	Experimental verification of Kirchhoff's and Ohm's laws. Investigation of potential distribution in an electric circuit.
3	Investigation of equivalent transformations of resistance connections according to the “star” and “triangle” schemes.
4	Experimental verification of the superposition method of energy sources in a linear electric circuit.
5	Investigation of an active DC two-poles.
Section 2 **LINEAR ELECTRICAL AC CIRCUITS OF SINGLE PHASE SINUOSIDE CURRENT**.	
6	Investigation of consumers serial connection in a sinusoidal current electric circuit.
7	Investigation of consumers parallel connection in a sinusoidal current electric circuit.
8	Investigation of consumers mixed connection in a sinusoidal current electric circuit.
9	Investigation of an electric circuit with mutual inductance in serial branches.

10	Investigation of an electric circuit with mutual inductance in parallel branches.
11	Investigation of electrical resonance in a series oscillatory circuit (voltage resonance).
12	Investigation of electrical resonance in a parallel oscillatory circuit (current resonance).
13	Investigation of transients in *RL* electrical circuit
14	Investigation of transients in *RC* electrical circuit

6. Self-study

№	Preparation for classroom classes
1	Preparation for classroom classes
2	Calculations and postprocessing based on primary data obtained in laboratory classes
3	Execution of independent works
4	Execution of calculation and graphic work
5	Preparation for Modular Control Work
6	Exam preparation

Policy and Conrol

7. Course policy

The system of requirements that the teacher puts before the student:

- rules for attending classes: in accordance with Order 1-273 of 14.09.2020, it is prohibited to assess the presence or absence of the applicant in the classroom, including the accrual of incentive or penalty points. According to the rating system of discipline, points are awarded for the relevant types of educational activity;
- rules of conduct in the classroom: the student has the opportunity to receive points for the relevant types of educational activities in lectures, practical and laboratory classes provided by the rating system of discipline. The use of communication tools to search for information on the teacher's Google drive, on the Internet, in a distance course on the Sikorsky platform is carried out at the direction of the teacher;
- rules of defense of laboratory works: laboratory work is defensed individually;
- rules of defense of individual tasks: the defense of calculation and graphic work (CGW) in the discipline is carried out individually (subject to compliance with the calendar plan of CGW);
- rules for assigning incentive points: incentive points are not included in the main rating scale, and their amount does not exceed 10% of the starting scale. Incentive points are awarded for participation in university and All-Ukrainian Olympiads in the Electrical engineering, participation in faculty and institute scientific conferences;
- policy of deadlines and rearrangements: untimely implementation of CGW and untimely defense of laboratory works provide for a reduction of the maximum score for a certain type of activity to 75%. The minimum score does not change and equals 60%. If the student did not pass or did not appear at the MCW, his/her result is evaluated in 0 points. In this case, it is possible to write an MCW, but the maximum score for it will be 75% of the maximum. Reassignment of defense of laboratory works, CGW and MCW is not provided;
- policy on academic integrity: The Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical conduct of individuals and provides a policy of academic integrity for employees and study at the university, which they should be guided in their activities, including the study and preparation of tests in the discipline "Electrical engineering and electronics;
- when using digital means of communication with the teacher (mobile communication, e-mail, correspondence on forums and social networks, etc.) it is necessary to adhere to generally

accepted ethical norms, in particular to be polite and limit communication during the teacher's working hours.

8. Types of control and rating system (RS) for assessing learning outcomes

Current control: MCW, CGW, laboratory work.
Calendar control: conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.
Semester control: exam
Conditions of admission to the semester control: minimally positive assessment for calculation and graphic work, enrollment of all laboratory works.

The overall rating of the student after the end of the semester consists of points obtained for:
- performance and defense of 14 laboratory works;
- performance of individual work (CGW) in two parts;
- performance of two parts of modular control work (MCW).

№	Type of control	Max. score	Number	Total
1.	MKW (p.1, p.2)	5	2	10
2.	CGW (p.1, p.2)	4	2	8
5.	Laboratory works	3	14	42
6.	Exam	40	1	40
	Total			100

Execution and protection of laboratory works

Weight score – 3.

The maximum number of points for all laboratory work – 3 points * 14 = 42 points.

The minimum number of points in the laboratory – 3 points * 14 *60%= 25,2 points.

Evaluation criteria:

- quality preparation for laboratory work (availability of a protocol, knowledge of the purpose of work, knowledge of the main theoretical provisions being tested), active participation in research, correct and neat processing of experimental results, clear answers to control questions on the topic – (0,9..1)*3 points;
- good preparation for laboratory work, active learning in the implementation of research, insignificant errors in the processing of experimental results, incomplete answers to control questions – (0,89..0,75)* 3 points;
- insufficient preparation for laboratory work, passive participation in research, significant errors in processing the results of experiments, partial answers to control questions – (0,74..0,6)*3 points;
- unpreparedness for laboratory work, passive participation in research, poor processing of results, incorrect answers to control questions on the topic of work – 0 points.

Individual semester task (CGW)

According to the working curriculum, each student performs computational and graphic work. RGR consists of two parts: "Calculation of a complex electric circuit of a direct current", "Calculation of a single-phase electric circuit of a sinusoidal current".

The maximum number of points for performing CGW – 4 points, minimum – 2,4 points.

Evaluation criteria:

- selection of the optimal method of calculation, correct execution of calculations with a full explanation, verification of the results of the solution, construction of the diagrams specified in the condition – (0,9..1)*(46) points;

- correct compilation of the system of equations and its solution, verification of the obtained results, absence of the diagrams specified in the condition – (0,89..0,75)*(4) points;

- correct compilation of the system of equations and its solution, lack of verification of the obtained results and diagrams specified in the condition – (0,74..0,6)*(4) points;

- solving a problem with fundamental errors – 0 points.

Modular control work

The modular control work consists of two parts: "Calculation of a complex electric circuit of a direct current", "Calculation of a single-phase electric circuit of a sinusoidal current", accordingly.

The task of each test consists of one task.

The weight score of each part of the MCW is 5 points.

The maximum score for MCW – 2 * 5 = 10 points.

Evaluation criteria:

- selection of the optimal method of calculation, correct execution of calculations with a full explanation, verification of the results of the solution, construction of the diagrams specified in the condition – (0,9..1)*5 points;

- correct compilation of the system of equations and its solution, verification of the obtained results, absence of the diagrams specified in the condition – (0,89..0,75)* 5 points;

- correct compilation of the system of equations and its solutions, lack of verification of the obtained results and diagrams specified in the condition – (0,74..0,6)*5 points;

- solving a problem with fundamental errors – 0 points.

Calendar control is based on the current rating. The condition of positive attestation is the value of the current student rating not less than 50% of the maximum possible at the time of attestation.

9. Additional information on the discipline (educational component)

List of questions to be submitted for semester control (as Appendix 1 to the syllabus)

Work program of the discipline (syllabus):

Compiled by Associate Professor of the Department of Theoretical Electrical Engineering FEA, Doct. of Tech. Sciences Shcherba Maksym

Approved by the Department of Theoretical Electrical Engineering FEA (protocol № 6 of 25.01.2021)

Approved by the Methodical Commission of the faculty [1] (protocol № __ of _____)

[1] Methodical council of the university - for general university disciplines.