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

Department of Translational Medical Bioengineering

FUNDAMENTALS OF ELECTRICAL ENGINEERING

Working program of basic discipline (Silabus)

Реквізити навчальної дисципліни	
Level of higher education	***First (bachelor's)***
Branch of knowledge	*16 Chemical and Bioengineering*
Specialty	*163 Biomedical Engineering*
Educational program	*Medical Engineering*
Discipline status	*Mandatory discipline*
Form of study	*full-time / day / mixed / remote*
Year of preparation, semester	*2th course, spring semester*
The scope of discipline	*5 ECTS credits / 150 hours*
Semester control / Control measures	*Exam, Modular Test Work*
Lessons schedule	*According to the schedule on the site http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about course leader / teachers	**Lecturer:** Associate Professor of the Department of TMB Oksana Serhiivna Bohomolova, e-mail – bohomolova@lll.kpi.ua, Telegram - @BohomolovaOksana. **Practical:** Associate Professor of the Department of TMB Oksana Serhiivna Bohomolova, e-mail – bohomolova@lll.kpi.ua, Telegram - @BohomolovaOksana.
Course placement	*https://do.ipo.kpi.ua/course/view.php?id=419*

Distribution of hours

Semester	Lectures	Practical	Laboratory	Independent Work
spring semester	*36*	*18*	*18*	*78*

Curriculum of the discipline

1. Description of the discipline, its purpose, subject of study and learning outcomes

The curriculum for the academic discipline "Fundamentals of Electrical Engineering" has been developed in accordance with the educational and professional program Medical Engineering of the first (bachelor's) level of higher education, specialty 163 Biomedical Engineering.

The main objective of the academic discipline "Fundamentals of Electrical Engineering" is to develop the professional competencies necessary for students to understand the principles of electrical equipment and the creation of hardware for biomedical systems.

The subject of study is the theoretical and practical aspects of working with electrical circuits and devices used in the medical field, in particular electrical phenomena and processes in biotechnical systems; methods for calculating and analyzing electrical circuits, which form the basis for further study of analog and digital circuitry; technical characteristics and principles of operation of electrical equipment used for prevention, diagnosis, and treatment; interaction of technical means with biological objects through the prism of electrical parameters.

General competencies *(OPP was put into effect by the Rector's Order NON/434/2024 of 10.06.2024 p.):*

ZK 02 *— Knowledge and understanding of the subject area and understanding of professional activities*

ZK 03 *–Ability to communicate in the official national language both orally and in writing*

ZK 04 *– Skills in using information and communication technologies*

ZK 08 *– Ability to make informed decisions*

ZK 09 *– Ability to communicate with representatives of other professional groups at different levels (experts from other fields of knowledge/types of economic activity)*

ZK 10 *– Skills in conducting safe activities*

ZK 11 *– Ability to assess and ensure the quality of work performed*

Special (professional) competencies *(OPP was put into effect by the Rector's Order NON/434/2024 of 10.06.2024 p.):*

FK 01 – *Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems*

FK 06 *– Ability to effectively use tools and methods for analysis, design, calculation, and testing in the development of biomedical products and services*

FK 10 *– Ability to apply the principles of modern automated control systems in the production of medical devices, their technical, algorithmic, informational, and software support*

FK 11 *– Ability to develop, plan, and conduct experiments using specified technical and biomedical techniques, applying mathematical methods in the analysis and modeling of the functioning of living organisms, systems, and processes in biology and medicine, computer processing, analysis, and synthesis of the obtained results.*

The program learning outcomes after studying the discipline "Microprocessor Engineering" are *(OPP was put into effect by the Rector's Order NON/434/2024 of 10.06.2024 p.):*

PRN 01 – *The ability to apply knowledge of the fundamentals of mathematics, physics and biophysics, bioengineering, chemistry, engineering graphics, mechanics, materials resistance and strength, properties of gases and liquids, electronics, computer science, signal and image acquisition and analysis, automatic control, system analysis, and decision-making methods at a level necessary for solving biomedical engineering tasks*

PRN 08 *– Understand theoretical and practical approaches to the creation and management of medical equipment and medical technology*

PRN 16 *– Ability to utilize computer-aided design and drafting systems for developing the technological and hardware schematics of medical devices and systems, taking into account the specifics of their components*

RPN 20 *– Knowledge and application of research methods in biomedical engineering, methods and tools for organizing and processing experimental data, statistical methods for modeling and simulating processes and systems of physical and biological nature, modern programming technologies and supporting tools, methods for designing digital and microprocessor-based medical systems*

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

The academic discipline “Fundamentals of Electrical Engineering” belongs to the cycle of professional training and is interdisciplinary in nature. In accordance with its subject matter, it integrates knowledge from the discipline “Physics” (ZO 08). According to the structural and logical scheme of training specialists in the specialty 163 “Biomedical Engineering,” “Fundamentals of Electrical Engineering” is the basis for studying further specialized disciplines, in particular “Analog and Digital Circuit Engineering” (PO 11).

3. The content of the discipline

The main sections and topics that will be considered in the process of studying the course:

Section 1. Linear DC Circuits

Topic 1.1: Basic concepts and laws of electrical circuits in biomedical engineering.

Topic 1.2: Tools and calculation methods for circuit design in biomedical products.

Topic 1.3: Non-linear electrical circuits and process modeling in medicine.

Section 2. AC Electrical Circuits

Topic 2.1: Fundamentals of sinusoidal current and the use of specialized software.

Topic 2.2: Resonance phenomena and their application in diagnostic equipment.

Topic 2.3: Three-phase circuits: connection schemes and load calculation.

Section 3. Transient Processes in Linear Circuits

Topic 3.1: Analysis of non-stationary processes during the power switching of medical equipment.

Topic 3.2: Classical and operational methods for analyzing biotechnical models.

Section 4. Electromagnetic Devices and Safety

Topic 4.1: Electrical safety and galvanic isolation according to medical standards.

Topic 4.2: Electrical machines and automated control in rehabilitation

4. Навчальні матеріали та ресурси

Basic literature:

1. Бойко В.С. Теоретичні основи електротехніки. Частина 1. Навчальний посібник [Електронний ресурс] : навчальний посібник для здобувачів ступеня бакалавра за освітніми програмами «Електричні системи і мережі», «Електричні станції» «Електричні машини і апарати», «Управління, захист та автоматизація енергосистем» «Електромеханічні системи автоматизації,електропривод та електромобільність», «Електротехнічні пристрої та електротехнологічні комплекси» «Нетрадиційні та відновлювані джерела енергії» / В. С. Бойко, Л. Ю. Спінул, М. П. Бурик, В. Ю. Лободзтнський ; КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 3,35 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2022. – 199 с. https://ela.kpi.ua/handle/123456789/47853

2. Бурик М.П. Лінійні електричні кола постійного струму: Розрахунково-графічна робота [Електронний ресурс] : навч. посіб. для студ. спеціальності 141 «Електроенергетика, електротехніка та електромеханіка», спеціалізацій «Електромеханічні системи автоматизації та електропривод», «Електричні машини і апарати», «Інжиніринг та автоматизація електротехнічних комплексів» й «Мехатроніка енергоємних виробництв» / М П. Бурик, Л. Ю. Спінул ; КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 2,51 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2018. – 46 с. https://ela.kpi.ua/handle/123456789/22658

3. Бурик М.П. Лінійні електричні кола однофазного синусоїдного струму: Розрахунковографічна робота [Електронний ресурс] : навч. посіб. для здобувачів ступеня бакалавра за освітніми програмами «Електротехнічні пристрої та електротехнологічні комплекси», «Нетрадиційні та відновлювальні джерела енергії», «Електричні станції», «Електромеханічні системи автоматизації, електропривод та електромобільність» та «Електричні машини і апарати» спеціальності 141 «Електроенергетика, електротехніка та електромеханіка» / М П. Бурик, Л. Ю. Спінул, В. Ю. Лободзинський; КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 19,7 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2021. – 150 с. https://ela.kpi.ua/handle/123456789/41134

4. Бурик М.П. Теоретичні основи електротехніки - 1: Лабораторний практикум [Електронний ресурс]: навч. посіб. для здобувачів ступеня бакалавра за освітніми програмою «Електротехнічні пристрої та електротехнологічні комплекси», «Нетрадиційні та відновлювальні джерела енергії», «Електричні станції», «Електромеханічні системи автоматизації та електропривод», «Електричні машини і апарати», спеціальності 141 «Електроенергетика, електротехніка та електромеханіка» / М. П. Бурик, Л. Ю. Спінул, В. Ю.

Лободзинський, Ю .В. Перетятко, О. О. Ілліна; КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 5,8 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2022. – 96 с. https://ela.kpi.ua/handle/123456789/47710.

5. Маляр В.С. Теоретичні основи електротехніки: Підручник: – Львів: Видавництво «Львівська політехніка», 2018. – 416 с.

6. Матвієнко М. П. Основи електротехніки та електроніки. Підручник. – К.: Видавництво «Ліра-К», 2017. – 504 с.

7. Хілов В.С. Теоретичні основи електротехніки: Дніпро: Національний технічний університет "Дніпровська політехніка", 2021.- 433 с.

8. Карпов Ю.О., Кацив С.Ш., Кухарчук В.В., Ведміцький Ю.Г. Теоретичні основи електротехніки. усталені режими лінійних електричних кіл із зосередженими та розподіленими параметрами. Підручник.–Херсон: «Олді-Плюс+», 2019. –326 с.

9. Паначевний Б.І., Свергун Ю.Ф. Загальна електротехніка.Підручник. – К.: «Каравела», 2018. – 296 с.

10. «Теоретичні основи електротехніки. Збірник задач: навчальний посібник» / укл. О.В.Корощенко, В.Ф.Денник, О.А.Журавель та ін.; за заг.ред. О.В.Корощенка.- Донецьк, ДВНЗ «ДонНТУ», 2012.- 673 с.

11. Гуржій А.М., Мещанінов С.К., Нельга А.Т., Співак В.М. Електротехніка та основи електроніки : Підручник. - Київ: «Літера ЛТД», 2020. - 288 с

12. Корощенко О.В. «Теоретичні основи електротехніки. Збірник задач: навчальний посібник» / укл. О.В.Корощенко, В.Ф.Денник, О.А.Журавель та ін.; за заг.ред. О.В.Корощенка.- Донецьк, ДВНЗ «ДонНТУ», 2012.- 673 с.

13. Спінул Л. Ю. Теоретичні основи електротехніки Частина 2: Навчальний посібник [Електронний ресурс]: навч. посіб. для здобувачів ступеня бакалавра за освітніми програмою «Електричні системи і мережі», «Електричні станції», «Електричні машини і апарати», «Управління, захист та автоматизація енергосистем», «Електромеханічні системи автоматизації, електропривод та електромобільність», «Електротехнічні пристрої та електротехнологічні комплекси», «Нетрадиційні та відновлювані джерела енергії» спеціальності 141 «Електроенергетика, електротехніка та електромеханіка» / Л.Ю.Спінул, М.П.Бурик, В.Ю.Лободзинський; О.О.Білецький, КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 9 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2022. – 167 с. https://ela.kpi.ua/handle/123456789/48889

14. Бурик М.П. Теоретичні основи електротехніки - 2: Лабораторний практикум [Електронний ресурс]: навч. посіб. для здобувачів ступеня бакалавра за освітніми програмою «Електротехнічні пристрої та електротехнологічні комплекси», «Нетрадиційні та відновлювальні джерела енергії», «Електричні станції», «Електромеханічні системи автоматизації та електропривод», «Електричні машини і апарати», «Електричні системи і мережі», «Управління, захист та автоматизація енергосистем» спеціальності 141 «Електроенергетика, електротехніка та електромеханіка» / М. П. Бурик, Л. Ю. Спінул, В. Ю. Лободзинський; Н. В. Беленок, Ю. М. Чуняк КПІ

ім. Ігоря Сікорського. – Електронні текстові данні (1 файл: 7,89 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2022. – 96 с. https://ela.kpi.ua/handle/123456789/48828

Additional literature:

1. Щерба А.А. Теоретичні основи електротехніки – 1. Електричні кола постійного та змінного струму. Чотириполюсники. Практикум [Електронний ресурс] : навчальний посібник для студентів спеціальності 141 «Електроенергетика, електротехніка та електромеханіка» / КПІ ім. Ігоря Сікорського ; уклад.: А. А. Щерба, Ю. В. Перетятко. – Електронні текстові дані (1 файл: 3,16 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2021. – 116 с.

2. Намацалюк І.Н. Теоретичні основи електротехніки. Збірник задач [Електронний ресурс] : навчальний посібник для студентів спеціальності 141 «Електроенергетика, електротехніка та електромеханіка» / КПІ ім. Ігоря Сікорського ; уклад.: І. Н. Намацалюк, Ю. В.

Перетятко. – Електронні текстові дані (1 файл: 2,43 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2020. – 113 с. https://ela.kpi.ua/handle/123456789/42079

Educational content

5. Methods of mastering the discipline (educational component)

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
1.	*Basic concepts and laws of electrical circuits in solving biomedical engineering problems:* *P1. Electrical circuits and their models. Basic concepts at the level necessary for solving biomedical engineering problems.* *P2. Ohm's and Kirchhoff's laws as a basis for obtaining and analyzing signals in biomedical systems.*	PRN 01	Laboratory work 1	1-2nd week
2.	*Tools and methods for calculating electrical circuits in the development of biomedical products:* *P1. Simplification of electrical circuits and equivalent star-delta transformations for analyzing medical equipment nodes.* *P2. The contour current method as a tool for calculating parameters in the development of biomedical products.* *P3. The node potential method, the equivalent generator method, and the principle of superposition in the analysis of medical device hardware circuits.*	PRN 16	Practical work 1 Laboratory work 2	3-4th week
3.	*Electric circuits with nonlinear elements and modeling of processes in medicine:* *P1. Analysis of circuits with semiconductors in medical sensors: application of mathematical methods in modeling processes in medicine.*	PRN 16	Practical work 2 Laboratory work 3	5th week
4.	*Fundamentals of sinusoidal current and use of software to present results:* *P1. Parameters of sinusoidal signals and their complex representation: use of engineering software packages to present results.* *P2. Impedance of biological tissues and electrodes: using knowledge of biophysics to analyze physical and biological systems.* *P3. Calculation of branched circuits and analysis of medical device filters using*	PRN 16 PRN 20	Practical work 3 Laboratory work 4	6-7th week

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
	computer-aided design systems.			
5.	*Resonance phenomena in electrical circuits and their application in diagnostic equipment:* *P1. Voltage resonance in therapeutic equipment: understanding the requirements of healthcare professionals for medical services.* *P2. Current resonance in wireless power transfer systems for implants: designing medical system components.*	*PRN 08* *PRN 16*	*Practical work 4* *Laboratory work 5*	*8-9th week*
6.	*Трифазні електричні кола: схеми з'єднання та розрахунок навантаження:* *Ч1. Схема «зірка» з нейтраллю для безпечного живлення операційних: врахування вимог до біомедичних продуктів у медичному контексті.* *Ч2. Розрахунок навантаження «трикутником» для МРТ: аналіз та проектування при розробці біомедичних продуктів.*	*PRN 08*	*Practical work 5* *Laboratory work 6*	*10-11th week*
7.	*Three-phase electrical circuits: connection diagrams and load calculation:* *P1. Star connection diagram with neutral for safe power supply to operating rooms: consideration of requirements for biomedical products in a medical context.* *P2. "Delta" load calculation for MRI: analysis and design in the development of biomedical products.*	*PRN 20*	*Practical work 6* *Laboratory work 7*	*12th week*
8.	*Classical and operator methods of biotechnical model analysis:* *P1. Classical method and formulation of differential equations for biotechnical models based on system analysis methods.* *P2. Operator method: Laplace transform for real-time analysis of complex modes using engineering software.*	*PRN 01*	*Practical work 7* *Laboratory work 8*	*13-14th week*
9.	*Electrical safety and galvanic isolation in accordance with medical standards:* *Part 1. Principles of transformer operation: ensuring patient safety through*	*PRN 08*	*Practical work 8*	*15th week*

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
	understanding the requirements for medical products.			
10.	*Modular control work*		*Practical work 9*	

Practical works

№ s/n	*Practical work topic*	*Duration in hours*
1	***Calculation of simple and complex direct current circuits using Kirchhoff's laws, loop currents, and/or node potentials*** *(Series, parallel, and mixed connections of resistors. Voltage and current sources. Application of Ohm's law to a branched circuit with a single EMF source. Sequence of calculation of an electrical circuit using Kirchhoff's laws)*	***2***
2	***Active two-terminal network method (equivalent generator).*** *(Sequence of calculations for an electrical circuit using the active two-terminal network method. Determination of equivalent parameters of a two-terminal network. Transfer of maximum power from an active two-terminal network to a passive one)*	***2***
3	***Calculation of sinusoidal signal parameters and biological tissue impedance in complex form.*** *(Representation of sinusoidal currents and voltages as complex numbers and vector diagrams. Calculation of electrical impedance)*	***2***
4	***Calculation of sinusoidal signal parameters and biological tissue impedance in complex form.*** *(Representation of sinusoidal currents and voltages as complex numbers and vector diagrams. Calculation of electrical impedance)*	***2***
5	***Calculation of sinusoidal signal parameters and biological tissue impedance in complex form.*** *(Representation of sinusoidal currents and voltages as complex numbers and vector diagrams. Calculation of electrical impedance)*	***2***
6	***Calculation of transient processes in circuits with a single energy storage device (RC and RL protection circuits)*** *(Calculation of dynamic characteristics of RC and RL circuits using the classical method. Determination of time constants and duration of transient modes in pulse therapy systems and surge protection circuits.)*	***2***
7	***Compilation of differential equations and the operator method for calculating biotechnical models*** *(Application of Laplace transformation to solve differential equations of the electrical state of complex systems. Formation of transfer functions of biotechnical models to analyze their response to arbitrary input signals****)***	***2***
8	***Calculation of medical transformer parameters to ensure galvanic isolation*** *(Calculation of key parameters for medical isolation transformers. Determination of transformation ratios, assessment of insulation resistance, and minimization of leakage currents in accordance with medical equipment safety standards.)*	***2***
9	***MCW*** *Calculation of a three-phase sinusoidal current circuit using the symbolic method****.***	***2***

Laboratory works

№ s/n	*Laboratory work topic*	*Duration in hours*
1	*Experimental verification of Kirchhoff's laws and modeling of a real voltage source.*	*2*
2	*Investigation of equivalent transformations of resistance combinations in star and delta configurations.*	*2*

3	*Investigation of an active DC two-terminal network..*	*2*
4	*Investigation of series and parallel connections of consumers in alternating current circuits using software.*	*2*
5	*Experimental investigation of voltage and current resonance in wireless power transmission systems.*	*2*
6	*Investigation of a three-phase electrical circuit when connecting the source and receiver in a star configuration with a neutral wire to ensure the safety of operating units.*	*2*
7	*Experimental investigation of the laws of commutation and the physical essence of processes in patient protection circuits.*	*2*
8	*Modeling of complex transient modes in real time using engineering software packages*	*2*
9	*Colloquium*	*2*

6. Independent student work

Types of independent work *(preparation for classroom sessions, performing calculations based on primary data obtained in laboratory sessions, solving problems, writing essays, performing calculation work, completing homework assignments, etc.):*

Independent work

№ s/n	List of topics and questions for independent study and references to educational literature	Number of hours of independent work by the student
Section 1. Linear direct current electrical circuits. List of questions for independent study		
1	SRC 1.1: Specific sources of EPC in biomedicine. Study of equivalent bioelectric potential circuits (heart, muscles) as sources of electrical energy. [1, P. 10–18; 11, P. 12–25.]	***6***
2	SRC 1.2: Features of calculating complex circuits using the node potential method. In-depth study of algorithms for automated calculation [2, Pp. 5–15; 5, Pp. 42–55]	***8***
3	SRC 1.3: Analysis of volt-ampere characteristics (VAC) of semiconductor elements in medical sensors. Nonlinear resistances and their approximation. [6, Pp. 145–160; 11, Pp. 88–104.]	***10***
Section 2. Alternating Current Electrical Circuits List of questions to be considered for independent study:		
4	SRC 2.1: Computer simulation of sinusoidal processes in environments (e.g. LTspice or Multisim). Visualization of phase shifts in biological tissues. [3, Pp. 10–22; 4, Pp. 24–30.]	***10***
5	SRC 2.2: Frequency characteristics of real components. The concept of Q-factor in wireless energy transfer systems for implants. [1, C. 120–135; 8, C. 95–110.]	**10**
6	SRC 2.3: Calculation of asymmetrical modes in three-phase power supply networks of clinics. Analysis of the consequences of a break in the neutral wire for medical equipment. [1, Pp. 160–175; 9, pp. 112–128.]	**8**
Section 3. Transients in linear electrical circuits *List of questions to be considered for independent study:*		
7	SRC 3.1: The influence of parasitic parameters on transient processes. Analysis of overvoltages when switching inductive loads (e.g. magnetic	**8**

№ s/n	List of topics and questions for independent study and references to educational literature	Number of hours of independent work by the student
	stimulators). [13, pp. 15–32; 5, pp. 210–225.]	
8	SRC 3.2: Application of Laplace transform for analysis of biophysical models. Transition from differential equations to algebraic operator forms. [13, pp. 45–60; 7, pp. 180–195.]	**8**
Section 3. Electromagnetic devices and safety ***List of questions to be considered for independent study:***		
9	SRC 4.1: Maintenance of protective equipment in medical premises. Classification of equipment by electrical safety types (types B, BF, CF).[11,pp. 250–270; 9, pp. 215–230.]	**6**
10	SRC 4.2: Principles of operation of stepper motors in precision medical manipulators and exoskeletons. [6, pp. 310–330; 11, pp. 195–210.]	**4**
Total		78

Policy and control

7. Policy of academic discipline (educational component)

Attending classes

Attendance at lectures is not compulsory. However, students are encouraged to attend classes, as they cover theoretical material and develop the practical skills needed to complete laboratory work. Attendance at practical classes is desirable, as they involve the defense of practical work.

The assessment system is focused on awarding points for student activity, as well as for completing tasks that develop practical skills and abilities.

Control measures missed

Missed tests (defense of practical work) must be made up in subsequent classes, provided that the assignment planned for the current class is completed, or during consultations.

The result of the modular control work for a student who did not attend the control event is zero. In this case, the student has the opportunity to write a modular control work at another time as agreed with the teacher.

Violation of deadlines and incentive points

Encouragement points	
Criterion	*Weight points*
Improving practical work	*1 points (for each practical work)*
Passing distance courses on topics that are agreed with teachers	*5 points*
Registration of scientific work for participation in the competition of student scientific works	*10 points*
Writing abstracts, articles, participation in international, national and / or other events or competitions on the subject of the discipline	*5 points*

Academic integrity

The policy and principles of academic integrity are defined in Section 3 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Norms of ethical behavior

Normative principles of behavior of students and employees, defined in sections 2 of the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute". Read more: https://kpi.ua/code.

Procedure for appealing the results of control measures

Students have the opportunity to raise any issue related to the control procedure and expect it to be addressed according to predefined procedures.

The student has the right to appeal the results of the control measure according to the approved provision on appeals in the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" (approved by the order №NON/128/2021 from 20.05.2021) - https://osvita.kpi.ua/index.php/node/182

Inclusive education

The discipline "Medical Microprocessor Systems" can be taught to most students with special educational needs, except for students with severe visual impairments who do not allow to perform tasks using personal computers, laptops and / or other technical means.

Distance learning

Distance learning takes place through the Sikorsky Distance learning Platform «Sikorsky».

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express control / test tasks, practical work).

Performance of practical works, and also performance of settlement and graphic work, is carried out during independent work of students in a remote mode (with a possibility of consultation with the teacher through e-mail, social networks).

Learning a foreign language

Teaching in English is carried out only for foreign students.

At the request of students, it is allowed to study the material with the help of English-language online courses on topics that correspond to the topics of specific classes.

8. Monitor and evaluate the system of evaluation of learning outcomes (Rating System of Evaluation)

Evaluation system (current control):

№ s/n	Control measure	Weight points	Number	Total

1.	Completion and defense of laboratory work	4	8	32
2.	Completion of practical work	1	6	6
3.	Modular control work (MCW)	12	1	12
4.	Exam	50	1	50
Total				100

Calendar control *(CC) - is performed twice a semester as monitoring of the current state of compliance with syllabus requirements.*

The purpose of calendar control is to improve the quality of student learning and monitor the implementation of the schedule of the educational process by students.

Criterion			The first CC	The second CC
Deadline of calendar controls			8th week	14th week
Conditions for obtaining a positive result from the calendar control	Current rating		≥ 12 балів	≥ 27 балів
	Practical work	PW № 1- 4	+	+
		PW № 5-9	-	+
	Laboratory work	LW № 1- 4	+	+
		LW № 5- 8	-	+
	Modular control work	Estimated MCW	-	+

In case of detection of academic poor quality during training - the control measure is not credited.

Semester assessment of students

Обов'язкова умова допуску до заліку		Критерій
1	Current rating	RD ≥ 27
2	Received a positive assessment for completed module control work	More than 6 points
3	All practical work are defended	More than 3 points
4	All laboratory work are defended	More than 19 points

The results are announced to each student separately in the presence or remotely (by e-mail). Also recorded in the system "Electronic Campus".

Optional conditions for admission to closure:

1. *Activity in practical classes.*
2. *Activity in laboratory classes.*
3. *Positive result of the first attestation and the second attestation.*
4. *Attending 50% of lectures.*

Table of translation of rating points to grades on a university scale:

Number points	Assessment on the university scale
100-95	Perfectly
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
Less 60	Unsatisfactorily
Admission conditions are not met	Not allowed

The exam consists of two theoretical questions on various topics from the syllabus and one practical task..

9. Додаткова інформація з дисципліни (освітнього компонента)

Appendix 1. Program learning outcomes (extended form)

In accordance with the Order of the Ministry of Education and Science of Ukraine No. 1204 dated November 19, 2018 "On approval of the standard of higher education in the specialty 163 Biomedical Engineering" for the first bachelor's level of higher education", in Appendix 1 establishes the correspondence of learning outcomes to competencies in the discipline "Fundamentals of Electrical Engineering".

Appendix 2. The list of questions for preparation for module control work

The list of questions for preparation for modular control work, and also for preparation for credit is given in Appendix 2.

Distance learning through additional online courses on certain topics is allowed subject to agreement with students. If a small number of students wish to take an online course on a specific topic, studying the material with such courses is allowed, but students must complete all the tasks provided in the discipline.

The list of courses is offered by the teacher after the students have expressed a desire (because the bank of available courses is updated almost every month).

The student provides a document confirming the completion of the distance course (in the case of a full course) or provides practical tasks from the distance course and subject to an oral interview with the teacher on the topics can receive grades for control measures provided for the studied topics (express control / test tasks, practical work).

Work program of the discipline (syllabus):

Compiled by *Associate Professor of the Department of Translational Medical Bioengineering, Ph.D. Oksana Serhiivna Bohomolova*

Approved by *the Department of Biomedical Engineering (protocol № 16 of June 21, 2024)*

Approved by *the Methodical Commission of the Faculty of Biomedical Engineering (protocol № 9 of June 26, 2024)*

Appendix 1.

For syllabus of the discipline «Fundamentals of Electrical Engineering»

Program learning outcomes (extended form)

As a result of studying the academic discipline " Fundamentals of Electrical Engineering ", students will be able to:

Learning outcomes (PRN)		Compliance of Learning Outcomes with Competencies according to the Higher Education Standard[6]	
		General Competencies (soft skills)	Special Competencies (professional)
PRN 1	*The ability to apply knowledge of the fundamentals of mathematics, physics and biophysics, bioengineering, chemistry, engineering graphics, mechanics, materials resistance and strength, properties of gases and liquids, electronics, computer science, signal and image acquisition and analysis, automatic control, system analysis, and decision-making methods at a level necessary for solving biomedical engineering tasks*	*ZK 03 Ability to communicate in the official national* *language both orally and in writing* *ZK 04 Skills in using information and communication technologies* *ZK 10 Skills in conducting safe activities*	*FC 01 Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems* *FC 10 Ability to apply the principles of modern automated control systems in the production of medical devices, their technical, algorithmic, informational, and software support*
PRN 8	*Understand theoretical and practical approaches to the creation and management of medical equipment and medical technology*	*ZK 02 Knowledge and understanding of the subject area and understanding of professional activities* *ZK 03 Ability to communicate in the official national language both orally and in writing* *ZK 04 Skills in using information and communication technologies* *ZK 08 Ability to make informed decisions* *ZK 10 Skills in conducting safe activities* *ZK 11 Ability to assess and ensure the quality of work performed*	*FC 01 Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems* *FC 06 Ability to effectively use tools and methods for analysis, design, calculation, and testing in the development of biomedical products and services* *FC 10 Ability to apply the principles of modern automated control systems in the production of medical devices, their technical, algorithmic, informational, and software support* *FC 11 Ability to develop, plan, and conduct experiments using specified technical and biomedical techniques,*

Learning outcomes (PRN)		Compliance of Learning Outcomes with Competencies according to the Higher Education Standard[6]	
		General Competencies (soft skills)	Special Competencies (professional)
			applying mathematical methods in the analysis and modeling of the functioning of living organisms, systems, and processes in biology and medicine, computer processing, analysis, and synthesis of the obtained results
PRN 16	*Ability to utilize computer-aided design and drafting systems for developing the technological and hardware schematics of medical devices and systems, taking into account the specifics of their components*	*ZK 02 Knowledge and understanding of the subject area and understanding of professional activities* *ZK 03 Ability to communicate in the official national language both orally and in writing* *ZK 08 Ability to make informed decisions* *ZK 09 Ability to communicate with representatives of other professional groups at different levels (experts from other fields of knowledge/types of economic activity)* *ZK 10 Skills in conducting safe activities* *ZK 11 Ability to assess and ensure the quality of work performed*	*FC 01 Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems* *FC 10 Ability to apply the principles of modern automated control systems in the production of medical devices, their technical, algorithmic, informational, and software support*
PRN 20	*Knowledge and application of research methods in biomedical engineering, methods and tools for organizing and processing experimental data, statistical methods for modeling and simulating processes and systems of physical and biological nature, modern programming technologies and supporting tools, methods for designing digital and microprocessor-based medical systems*	*ZK 02 Knowledge and understanding of the subject area and understanding of professional activities* *ZK 04 Skills in using information and communication technologies* *ZK 08 Ability to make informed decisions* *ZK 09 Ability to communicate with representatives of other professional groups at different levels (experts from other fields of knowledge/types of economic*	*FC 01 Ability to apply engineering software packages for research, analysis, processing, and presentation of results, as well as for automated design of medical devices and systems* *FC 06 Ability to effectively use tools and methods for analysis, design, calculation, and testing in the development of biomedical products and services* *FC 11 Ability to develop, plan, and conduct experiments*

Learning outcomes (PRN)		Compliance of Learning Outcomes with Competencies according to the Higher Education Standard[6]	
		General Competencies (soft skills)	Special Competencies (professional)
		activity) *ZK 11 Ability to assess and ensure the quality of work performed*	*using specified technical and biomedical techniques, applying mathematical methods in the analysis and modeling of the functioning of living organisms, systems, and processes in biology and medicine, computer processing, analysis, and synthesis of the obtained results.*

[6] Order of the Ministry of Education and Science of Ukraine No. 1204 dated November 19, 2018 "On approval of the standard of higher education in the specialty 163 Biomedical Engineering" for the first bachelor's level of higher education".

Appendix 2.

For syllabus of the discipline " Fundamentals of Electrical Engineering "

The list of questions for preparation for module control work, and also for preparation for test

1. *Define an electrical circuit and its main elements in the context of biomedical systems.*
2. *Formulate Ohm's law for a section and for a complete circuit. Explain the concept of internal resistance of a medical signal source.*
3. *Kirchhoff's first and second laws: physical essence and methodology for compiling equations.*
4. *Method for calculating the power balance in an electrical circuit.*
5. *Series, parallel, and mixed connections of resistors. Equivalent resistance.*
6. *Equivalent star-delta transformations and their application to the analysis of medical equipment nodes.*
7. *The essence of the loop current method. In which cases is its use appropriate?*
8. *The node potential method: calculation algorithm and advantages in the analysis of multi-node circuits.*
9. *The principle of superposition (overlay) and the limits of its application.*
10. *The equivalent generator theorem (active two-terminal network method).*
11. *The concepts of open-circuit voltage and input resistance*
12. *Classification of nonlinear elements. VAC of semiconductor diodes and their role in medical sensors.*
13. *Graphical methods for calculating nonlinear direct current circuits.*
14. *Basic parameters of a sinusoidal signal: amplitude, phase, frequency, period.*
15. *Effective and average values of sinusoidal current and voltage.*
16. *Complex representation of sinusoidal quantities. The relationship between time and complex forms.*
17. *Resistive element in an alternating current circuit: the relationship between current and voltage phases.*
18. *Inductive element in an alternating current circuit: inductive resistance and phase shift.*
19. *Capacitive element in an alternating current circuit: capacitive resistance and the concept of displacement current.*
20. *Total complex impedance and admittance. Resistance triangle.*
21. *Electrical model of biological tissue: active and reactive components of bioimpedance.Поняття активної, реактивної та повної потужності в колах змінного струму. Коефіцієнт потужності.*
22. *Voltage resonance in a series RLC circuit: conditions for occurrence and frequency characteristics.*
23. *Current resonance in a parallel RLC circuit: conditions for occurrence and application.*
24. *Application of the resonance phenomenon in therapeutic equipment (UHF, microwave therapy).*
25. *Principles of wireless energy transfer for implants based on magnetic resonance.*
26. *Principle of obtaining a three-phase EMF system. Advantages of three-phase systems.*
27. *Star connection of source and consumer phases. Relationship between line and phase values.*
28. *The role of the neutral (zero) wire in three-phase power systems for medical facilities.*
29. *Consequences of a neutral wire break under an asymmetrical load.*
30. *Connecting consumers in a "delta" configuration. Calculating currents and voltages.*
31. *Power of a three-phase circuit under symmetrical and asymmetrical loads.*
32. *Features of connecting heavy diagnostic equipment (MRI, X-ray machines) to a three-phase network.*
33. *Concepts of grounding systems (TN-S, IT) in operating rooms and intensive care units.*
34. *Causes of transient processes. Concept of commutation.*
35. *First and second laws of commutation. Initial conditions.*
36. *Transient processes in RC circuits: charging and discharging of a capacitor. Time constant.*
37. *Transient processes in RL circuits: rise and fall of current in inductance.*
38. *Classical method of calculating transient processes: composing and solving differential equations.*
39. *Free and forced components of the transient process.*
40. *Operator method of calculation: Laplace transform and transition to algebraic equations.*
41. *Laplace transform for the main circuit elements (R, L, C).*
42. *Analysis of non-stationary processes in defibrillators and patient protection circuits.*
43. *Principle of operation of a single-phase transformer. Transformation ratio.*
44. *Galvanic isolation: physical essence and significance for patient safety (IEC 60601 standard).*
45. *Transformer operating modes: no-load, operating mode, short circuit.*

46. *Classification of electrical machines: DC and AC motors.*
47. *The principle of operation of an asynchronous motor and its use in medical drives.*
48. *Stepper motors and servo drives: features of application in prosthetics and rehabilitation robotics.*
49. *Leakage currents in medical equipment: types, standards, and control methods.*
50. *Principles of construction of modern automated medical device control systems.*