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

Department of
biomedical engineering

Biomedical sensor systems

Working program of basic discipline (Syllabus)

Requisites for basic discipline

Level of higher education	***First (bachelor's)***
Branch of knowledge	***16 Chemical and Bioengineering***
Specialty	***163 Biomedical Engineering***
Educational program	***Medical engineering***
Discipline status	***Selective discipline***
Form of study	***full-time / day / mixed / remote***
Year of preparation, semester	***3th course, Spring semester***
The scope of discipline	***4 ECTS credits / 120 hours***
Semester control / Control measures	***Test Work, Modular Test Work, Abstract***
Lessons schedule	***According to the schedule on the site https://schedule.kpi.ua/***
Language of instruction	***Ukrainian***
Information about course leader / teachers	***Lecturer: Associate Professor,Bogomolov Mykola,*** nbogom@yahoo.com; mfbogomolov@gmail.com; m.bogomolov@kpi.ua ***Practical: Associate Professor,Bogomolov Mykola,*** nbogom@yahoo.com; mfbogomolov@gmail.com; m.bogomolov@kpi.ua ***Zoom: 779 2233 9663, code 7Pzg7d***
Teacher's profile	***Lecturer:*** **http://intellect.bmi.fbmi.kpi.ua/profile/bmf**
Course placement	***Platform «Sikorsky»*** **https://do.ipo.kpi.ua/user/index.php?id=5661**

DISCIPLINE PROGRAM

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

The purpose of discipline

The main goal of the academic discipline ***"Biomedical Sensor Systems"*** is to develop in students the ability to choose basic and auxiliary materials, methods and tools for the implementation of technical projects, to apply modern optoelectronic methods and modeling methods in the design of medical equipment and medical products; to conduct experiments according to given technical and medical methods, to perform computer and optical processing, analysis and synthesis of the results of optoelectronic research.

Teaching methods

Lectures are held using the explanatory and illustrative method, the problem-based presentation method, and the interactive method during lecture sessions, which is used to establish a dialogue with the audience**.**

Practical classes are held using:

1) Reproductive method, thanks to which students consolidate the studied theoretical material and learn to use it in specific scientific tasks.

2) Partial search, or heuristic method, which teaches the search for the right ways and methods

of solving problems.

3) Interactive method, which is used during practical classes to involve students in the processes of solving problems and the theoretical facts that are used for this. Presentation and discussion of the results obtained involves the use of problem-based and interactive learning methods**.**

Applicants independently study literature, software tools for designing medical devices and systems, medical monitoring and forecasting systems, Internet metrology systems, and diagnostic devices. For original solutions, academic work can develop into scientific research.

Software competencies

Integral competence

IK	***The ability to solve complex tasks and problems in biomedical engineering or in the process of learning, which involves conducting research and/or implementing innovations and is characterized by uncertainty of conditions and requirements***

Studying the educational component strengthens the following general competencies:

ZK 1	***Ability to apply knowledge in practical situations. (Reinforcement).***
ZK 2	***Knowledge and understanding of the subject area and understanding of professional activity (Reinforcement).***
ZK 4	***Skills in using information and communication technologies (Reinforcement).***
ZK 13	***The ability to preserve and multiply the moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and engineering, to use various types of physical activity for active recreation and leading a healthy lifestyle (Reinforcement).***
	Ability to evaluate and ensure the quality of training on modern biomedical sensors.
	Ability to generate new ideas (creativity) when performing practical work on biosensor design.
	Ability to make informed decisions when designing modern biomedical sensor systems.

Studying the educational component strengthens the following special (professional) competencies:

FK 2	***Ability to provide engineering and technical expertise in the planning, development, evaluation, and specification of medical equipment (Reinforcement).***
FK 7	***Ability to plan, design, develop, install, operate, maintain, service, control and coordinate the repair of devices, equipment and systems for prevention, diagnosis, treatment and rehabilitation used in hospitals and research institutes (Reinforcement).***
FK 12	***Ability to ensure and monitor compliance with safety and biomedical ethics when working with medical equipment (Reinforcement).***
	The ability to provide technical and functional characteristics of biosensor medical systems and devices that use modern advances in medicine and biology (in prevention, diagnostics, treatment and rehabilitation).
	The ability to apply physical, chemical, biological and mathematical methods in the analysis and modeling of the functioning of modern biomedical sensor systems and living organisms.

Studying the educational component reinforces the following program learning outcomes:

PRN 3	*Manage complex activities or projects, be responsible for making engineering decisions in unpredictable conditions, conduct feasibility and safety assessments of projects (Reinforcement).*
PRN7	*Provide engineering support, service, and technical maintenance during the operation of laboratory analytical equipment, medical diagnostic and therapeutic complexes and systems in accordance with the rules established by technical documentation and regulatory documents governing the procedures for commissioning, application, and repair of medical equipment, as well as to form the standard documentation by types of work according to the technical regulation on medical devices (Reinforcement).*
PRN10	*Be able to plan, organize, direct and control medical and bioengineering systems and processes (Reinforcement).*
PRN13	*Be able to analyze signals transmitted from organs to devices and process diagnostic information (signals and images) (Reinforcement).*
PRN22	*Knowledge of general principles and structure of complex biological systems, including the human body and its functions from the perspective of a systemic approach and their utilization in biomedical engineering, as well as basic methods and tools used for quantitative assessment of physiological system functioning (Reinforcement).*
PRN 23	*Development and implementation of modern diagnostic and therapeutic methods associated with the use of biotechnology, computer, and nanotechnology through the improvement of technical elements of medical devices and systems, as well as medical products, in the process of professional activity (Reinforcement).*
PRN24	*Being able to consider historical, social, environmental, ethical, legal, economic aspects, requirements of labor protection, industrial hygiene, and fire safety when forming technical solutions, taking into account the strengthening and preservation of personal and public health (Reinforcement).*
	Knowledge of the principles of development and modern problems of creating biosensor nanoelectronic diagnostic systems and implementing research results into medical practice.
	Formulate logical conclusions and substantiated recommendations regarding the evaluation, operation, and implementation of modern biomedical sensor systems.
	Apply the provisions of regulatory and technical documents that regulate the procedure for certification of modern biosensors and certification of their production.
	Be able to use databases, mathematical and software for data processing and computer modeling of modern biomedical sensor systems.
	Knowledge of methods for studying objects, analyzing and processing experimental data when studying modern biomedical sensor systems.
	Possession of modern methods for testing the experimental integrity and performance of modern biomedical sensor systems and determining their characteristics.

Program learning outcomes, assessment measures, and deadlines are announced to students at the first lesson.

Subject of the discipline. The academic discipline belongs to the cycle of selective academic disciplines of professional training of a specialist in specialty **163 "Biomedical Engineering"** with specialization in **"Medical Engineering"** of the first (bachelor's) level of higher education of a bachelor's degree, which provides the process of education and training of specialists with higher education with knowledge of the main modern laboratory methods for the study of human diseases, which are used in laboratory analytical techniques, which will allow them to design and operate highly efficient diagnostic optoelectronic devices, perform their repair and maintenance, and conduct scientific research on the impact of various harmful external factors on the human body. The practical part is aimed at direct familiarization with medical diagnostic technologies and relevant modern medical equipment directly in medical institutions: scientific and analytical examination, design, construction, research, testing, operation and technical expertise, engineering and information support of laboratory analytical equipment and technologies, computer processing of experimental medical information and signals to identify the presence of pathological areas, organs and tissues. ***The syllabus*** of the academic discipline **"Biomedical Sensory Systems"** is developed on the basis of the principle of constructive alignment, which allows to foresee the necessary educational tasks and activities that students need to achieve the expected learning outcomes based on a modern strategy of interaction between the teacher and the student in the electronic space in order to master the material and develop their practical skills, and then to design the learning experience in such a way as to maximize the students' opportunities to achieve the desired results. To complete each subsequent task, students need to apply the skills and knowledge obtained in the previous one. Special attention is paid to the principle of encouraging students to active learning, in accordance with which students should work on practical thematic tasks that will allow them to solve real problems and tasks in the future.

During learning, the following teaching methods are used:

- communicative, problem-based, research, explanatory-demonstrative, partial-based, and educational project methods;
- lecture courses, seminars, and practical classes, computer workshops and laboratory work, course projects, consultations, independent training in library collections, use of Internet resources, application of information and communication technologies (e-learning, online lectures, distance learning), completion of a bachelor's degree thesis;
- strategies of active and collective learning;
- personality-oriented developmental technologies based on active forms and methods of learning (team-based learning, pair work (think-pair-share), brainstorming method, case study method, business games, discussion, etc.);
- heuristic methods (methods of generating ideas, methods of solving creative tasks, methods of activating creative thinking);
- the method of problem-oriented learning.

For more effective communication in order to understand the structure of the academic discipline and master the material, e-mail and the WhatsApp messenger, Skype, the platform https://do.ipo.kpi.ua are used, with the help of which:

- the placement and exchange of educational material is simplified;
- feedback is provided to students regarding educational tasks and the content of the academic discipline;
- students' educational tasks are evaluated;
- students' implementation of the academic discipline plan, the schedule of educational tasks and student evaluation are recorded.

During training and for interaction with students, modern information, communication and network technologies are used to solve educational tasks such as **ZOOM** and **Cisco Webex Meetings**, as well as equipment (projector and electronic presentations for lectures and practical classes).

Program learning outcomes: As a result of studying the academic discipline **"Biomedical Sensor Systems"**, students will be able to:

1. Choose basic and auxiliary materials, methods and tools for the implementation of technical projects, apply modern methods and methods of modeling in the design of medical equipment and medical products.

2. Use methods and tools for quantitative assessment of the functioning of physiological systems in practical engineering activities.
3. Implement modern diagnostic and therapeutic methods associated with the use of biotechnology, computer and nanotechnologies.
4. Conduct experiments using specified technical and medical methods, perform computer processing, analysis and synthesis of the results obtained.
5. Implement modern diagnostic and therapeutic methods associated with the use of biotechnology, computer and nanotechnologies.
6. Improve the technical elements of medical devices and systems and medical products in the process of professional activity.
7. Apply methods and tools of prediction and modeling to study the behavior and properties of biological systems.
8. Work with information: find, evaluate and use information from various sources necessary for solving scientific and professional tasks

The correspondence of learning outcomes to the competencies in the Higher Education Standard can be viewed in **Appendix 1 "Program learning outcomes (extended form)".**

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

The discipline **"Biomedical Sensory Systems"** is interdisciplinary in nature. It integrates knowledge from other educational and scientific fields in accordance with its subject, in the structural and logical scheme of the specialist training program it provides the following educational disciplines and credit modules: 1). Mathematical modeling and simulation of biomedical systems; 2). Modeling of biophysical systems and processes in medicine; 3). Mathematical methods of optimizing biomedical signals and images; 4). Methods of identifying, processing and optimizing medical information; 5). Quantitative physiology; 6). Instrumental methods of diagnosing human health, as well as disciplines of the block of language and practical training.

The discipline **"Biomedical Sensory Systems"** is the basis for the preparation of bachelor's theses (projects, master's theses) in the specialty and in further practical work in the specialty.

Required skills: 1. Knowledge and skills in using **Microsoft Word, Microsoft PowerPoint**.

2. Ability to abstract thinking, analysis and synthesis of the latest technologies using modern optoelectronic diagnostic techniques, medical protocols and diagnostic devices.
3. Ability to search, process, analyze scientific and technical information from various sources for optimal use and implementation of medical and technical requirements for the application of modern medical technologies of optoelectronic diagnostics and treatment.
4. Knowledge of a foreign language.
5. Ability to work in a team of like-minded people and specialists in modern optoelectronic and laser fields of knowledge and laboratory research technologies.
6. Ability to work in an international context to participate in comprehensive testing and advertising of achievements of scientific and research works on the implementation of modern physiotherapeutic treatment technologies.
7. Ability to analyze complex medical engineering and bioengineering problems and tasks, to formalize them to find quantitative solutions using modern statistical mathematical methods and microcomputer information technologies when using optoelectronic laboratory devices.
8. Ability to investigate biological and technical aspects of the functioning and interaction of artificial biological neural networks and optoelectronic biotechnical systems.

2. Content of the academic discipline "Biomedical Sensor Systems"

Program learning outcomes, assessment measures, and deadlines are announced to students at the first lesson.

№ s/n	Subject	Program learning outcomes	The main tasks	
			Control measure	Deadline
1.	Basic mathematical relationships and features of calculations when registering human biophysical signals. Be able to analyze signals transmitted from organs to devices.	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work*** 1-2	***1-2nd week***
2.	Features of medical and diagnostic complexes. Features of processing diagnostic information.	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work*** 3-4	***3-4th week***
3.	Features of human biosignals	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work*** 5-8	***5-6th weeks***
4.	Basic functional signals transmitted from organs to devices.	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work*** 9-10	***7-8th weeks***
5.	Biophysical mechanism of biopotentials in excitable cells. Modeling the functioning of modern biomedical sensor systems and living organisms.	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Abstract***	***9-10th weeks***
6.	Features of biomedical sensor systems for cardiological research	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work*** 11-14	***11-12th weeks***
7.	Basic concepts of measuring transducers. Computer processing, analysis and synthesis of the obtained results.	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Practical work*** 15-18	***13-14th weeks***
8.	Metrological characteristics of measuring biomedical transducers. Modeling the functioning of modern biomedical sensor systems and living organisms.	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Home Control Work***	***15-16th weeks***
9.	Schematics of strain-resistive and fiber-optic tip blood pressure transducers.	PRN3, PRN7, PRN 10, PRN13, PRN22, PRN23, PRN 24	***Test***	***17-18th weeks***

	Biomechanical and bioacoustic transducers			

3. Training materials and resources

Basic literature:

1. Сучасні оптоелектронні діагностичні прилади [Електронний ресурс] : навчальний посібник для здобувачів ступеня бакалавра за освітньою програмою «Медична інженерія» спеціальності 163 «Біомедична інженерія» / КПІ ім. Ігоря Сікорського ; уклад. М. Ф. Богомолов, В. Б. Максименко, В. В. Шликов ; КПІ ім. Ігоря Сікорського. – Електронні текстові данні (1 файл 4,3 Мбайт). – Київ : КПІ ім. Ігоря Сікорського», 2021. – 125 с.
2. Богомолов М., Орець Є. "Багатофункціональний стимулятор біологічно активних точок"/In: LAP LAMBERT Academic Publishing is a trademark of Dodo Books Indian Ocean Ltd., member of the OmniScriptum S.R.L Publishing group, str. A.Russo 15, of. 61, Chisinau-2068, Republic of Moldova Europe. 2021, ISBN: 978-620-3-93050-4. 69 p.
3. Богомолов М., ДанилецьМ.. "Універсальний мультихвильовий лазерний комплекс для офтальмології /In: LAP LAMBERT Academic Publishing is a trademark of Dodo Books Indian Ocean Ltd., member of the OmniScriptum S.R.L Publishing group, str. A.Russo 15, of. 61, Chisinau-2068, Republic of Moldova Europe. 2021, ISBN: 978-620-3-93050-1. 65 p.

Additional literature (electronic resources):

1. В. Вуйцік, І. Шедрєєва, О. В. Осадчук, Т. Б. Мартинюк, і О. В. Мозговий, «Застосування оптичних волоконних сенсорів для контролю температурних режимів в апаратурі медичного призначення», Вісник ВПІ, вип. 1, с. 121–127, Лют. 2025.

URL: https://doi.org/10.31649/1997-9266-2025-178-1-121-127 (дата звернення: 06.04.25).

2. Yimin Luo, Shijia Chen, Cheng Wang. Design and evaluation of FBG-based vascular shape reconstruction sensors through animal experiments. 2025, 117769, ISSN 0263-2241.

URL: https://doi.org/10.1016/j.measurement.2025.117769.

3. Katrenova Z., Alisherov S., Abdol T., Molardi C., Status and future development of distributed optical fiber sensors for biomedical applications, February 2024. Sensing and Bio-Sensing Research, vol. 43.

URL: https://doi.org/10.1016/j.sbsr.2023.100616 (дата звернення: 06.04.25).

4. Zhanerke Katrenova, Shakhrizat Alisherov. Status and future development of distributed optical fiber sensors for biomedical applications, Sensing and Bio-Sensing Research, Vol. 43. 2024.

URL: https://doi.org/10.1016/j.sbsr.2023.100616

5. Yu K, Chen W, Deng D, Wu Q, Hao J. Advancements in Battery Monitoring: Harnessing Fiber Grating Sensors for Enhanced Performance and Reliability. *Sensors*. 2024; 24(7):2057.

URL: https://doi.org/10.3390/s24072057

6. Gangwar, R.K.; Kumari, S.; Pathak, A.K.; Gutlapalli, S.D.; Meena, M.C. Application of Optical Fibers in Temperature Monitoring. Encyclopedia, 2023.

URL: https://encyclopedia.pub/entry/41649 (дата звернення: 06.04.25).

7. Mulindi, J. Basics of Biomedical Instrumentation Systems. May 2020. https://www.biomedicalinstrumentationsystems.com/optical-fiber-sensors-and-their-applications-in-medical-field/ (дата звернення: 06.04.25).
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URL: doi: 10.1109/JPHOT.2018.2829623.
10. Carotenuto B, Ricciardi A, Micco A, Amorizzo E, Mercieri M, Cutolo A, Cusano A. Smart Optical Catheters for Epidurals. *Sensors*. 2018.
URL: https://doi.org/10.3390/s18072101
11. Schena, E.; Tosi, D.; Saccomandi, P.; Lewis, E.; Kim, T. Fiber Optic Sensors for Temperature Monitoring during Thermal Treatments: An Overview. Sensors 2016.
URL: https://doi.org/10.3390/s16071144 (дата звернення: 06.04.25).
12. Sven Poeggel, Dineshbabu Duraibabu. Recent Improvement of Medical Optical Fibre Pressure and Temperature Sensors. Biosensors 2015.
URL: doi:10.3390/bios5030432
13. Sven Poeggel, Daniele Tosi. Optical Fibre Pressure Sensors in Medical Applications. Sensors 2015.
URL: doi:10.3390/s150717115
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15. Yoon J., Jo S., Chun I. S., Jung I., Kim H.-S., Meitl M., Menard E., Li X., Coleman J. J., Paik U., Rogers J. A. GaAs photovoltaics and optoelectronics using releasable multilayer epitaxial assemblies // Nature. — 2010. — Vol. 465. — P. 329–333. — DOI: https://rogersgroup.northwestern.edu/files/2010/naturegaas.pdf
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20. MicroLED-Info. Apple - microLED status [Електронний ресурс]. — Режим доступу: https://www.microled-info.com/apple?utm_source=chatgpt.com (дата звернення: 02.06.2025)
21. Wikipedia. Karl Deisseroth [Електронний ресурс]. — Режим доступу: https://en.wikipedia.org/wiki/Karl_Deisseroth (дата звернення: 02.06.2025)
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23. Injectable, Cellular-Scale Optoelectronics with Applications for Wireless Optogenetics Tae-il Kim Science et al. 340 , 211 (2013); DOI: https://rogersgroup.northwestern.edu/files/2013/injectable.pdf
24. Neurolux Publications. [Електронний ресурс] / Режим доступу до ресурсу: http://www.neurolux.org/ (дата звернення: 20.05.2025).

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(electronic resources):

1. http://info-library.com.ua/books-text-4072.html.
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3. Електронний кампус. Викладач М.Ф.Богомолов.
4. http://info-library.com.ua/books-text-4072.html.
5. http://www.twirpx.com.
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7. http://info-library.com.ua/books-text-4072.html .
8. http://ela.kpi/handle/123456789/11560.
9. http://ela.kpi.ua/handle/123456789/16554.

Educational content

4. Methodology for mastering the academic discipline (educational component) "Biomedical Sensor Systems"

Information (by sections, topics) about all training sessions (lectures, practicals, seminars):

Names of sections and topics	Number of hours					
	Total	including				
		Lectures	Practical (seminar)	Computer workshops	Laboratory	Independent student work
1	2	3	4	5	6	7
Section 1. Basic mathematical relationships and features of calculations when registering human biophysical signals.						
Topic 1.1. Features of optoelectronic methods of biomedical research.	10	4				6
Topic 1.2. Basic mathematical relationships and features of calculations when registering human biophysical signals.	10	2	2			6
Topic 1.3. . Photodynamic effect of endogenous sensitizer. Interaction of optical radiation with biological objects.	10	2	2			6
Topic 1.4. Optical methods in laboratory diagnostics.	12	6	4			2
Topic 1.5. Features of medical and	3					3

Names of sections and topics	Number of hours					
	Total	including				
		Lectures	Practical (seminar)	Computer workshops	Laboratory	Independent student work
diagnostic complexes						
Total by section 1	**45**	**14**	**8**			**23**
Section 2. Metrological characteristics of biomedical measuring transducers						
Topic 2.1 Biophysical mechanism of the emergence of biopotentials in excitable cells.	10	2	4			4
Topic 2.2. Basic optical schemes for measuring the characteristics of fiber-optic transmission paths of biomedical information.	7	1	2			4
Topic 2.3. Optoelectronic circuit of a medical interferometric optoelectronic analyzer of bioobjects	5	1	2			2
Topic 2.4. Features of biomedical sensor systems for cardiological research	14	2	2			10
Topic 2.5. Optoelectronic circuit of a medical interferometric analyzer of bioobjects	12	2	2			8
Topic 2.6. Basic concepts of measuring transducers.	12	2	2			8
Topic 2.7 Schematics of strain-resistive and fiber-optic tip blood pressure transducers. Transducers of biomechanical and bioacoustic quantities.	10	2	4			4
Total by section 2	**70**	**12**	**18**			**40**
Modular test work	5		2			3
Total hours	**120**	**26**	**28**	–		**66**

Recommendations for mastering training sessions (in the form of a detailed description of each lesson and planned work):

Lectures

List of didactic tools for lectures: Lecture notes, projection multimedia equipment; Power Point presentation.

№ s/n	Title of the lecture topic and list of main questions (list of didactic tools, references to literature and tasks on ISW)	Number of hours
1	**Basic mathematical relationships and features** of calculations when registering human biophysical signals. Main advantages of using optoelectronic methods and devices for diagnosing human diseases. The main purpose of using diagnostic optoelectronic device systems and biomedical equipment. Technical means, parameters and characteristics of automatic biomedical equipment design systems. Basic principles of creating automatic biomedical equipment design systems. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.** **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources[3, P.34-78;5, P.26-52;7, P.47-59].**	4
2	**Features of medical and diagnostic complexes.** The principle of photodynamic influence and stimulation of formed elements of human blood. Principles of completeness, development, compatibility, standardization and inventory, inclusion and accumulation of experience. Mathematical formulation of the problem of designing biomedical equipment, selection of numerical methods of analysis, development of a design algorithm, mathematical models and methods. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.** **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [2, P.19-25; 3, P. 41-53; 4,P. 10-17.].**	2
3	**Biophysical mechanism of biopotentials in excited cells.** Structure and principle of operation of helium-neon, argon and molecular lasers. Electrical and optical characteristics of semiconductor laser diodes. Physical foundations of the formation of the inversion state of the active substance for a gas medium and a semiconductor crystal. Structural diagrams of modern atomic, ionic and molecular lasers. Energy diagrams of an active gas medium and semiconductors. Energy diagram of a degenerate semiconductor. Areas of application, optical diagrams of quantum devices in modern optoelectronic measuring systems. Mathematical equations describing the inversion state of the active substance, model and calculation of optical diagrams of modern optoelectronic devices. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.** **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [4,P.34-58;7,P.26-47;9,P.38-51.].**	3
4	**Basic concepts of measuring transducers.** Basic characteristics of fiber optic cables. Methods of measuring the numerical aperture of fiber optic cables. Dispersion of fiber optic cables, basic types and measurement schemes. Mechanisms of radiation attenuation in fiber optic cables, methods and modern devices for measuring losses in optical paths. Collapsible and non-collapsible fiber optic connectors. Methods of monitoring and measuring radiation propagation parameters in optical cables when designing modern telecommunication systems. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.** **Tasks for the SRS:**	2

	1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [4, P. 28-43; 6, P.37-51; 9, P.48-62.].	
5	**Optoelectronic circuit of a medical interferometric optoelectronic analyzer of bioobjects.** Calculation of technical characteristics of the radiation source of fiber-optic medical systems. Minimum permissible radiation power at the input of the photodetector. Transmission speed of useful information. Losses of radiation power due to packaging of fiber optic cables. Calculation of the main losses of radiation power in fiber-optic paths. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.** **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [2, P.25-38; 7, P.46-53; 9, P.67-81.].**	**3**
6	**Modern optoelectronic diagnostic medical measuring devices, interferometers, spectrophotometers and fiber-optic sensors.** Features of object-oriented methods of designing biomedical equipment. Fiber-optic converters with phase modulation. Basic modern optical schemes of Mach-Zehnder and Michelson interferometers. Laser fiber-optic Doppler velocity meters of differential and heterodyne types. Fiber-optic gyroscopes. Fiber-optic converters for measuring magnetic and electric fields, temperature, vibration loads, microdisplacements of objects, microcurrents of biological signals. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.** **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [2, P.15-28;8,P.25-47;10,P.44-57.].**	**3**
7	**Optoelectronic circuit of a medical interferometric analyzer of bioobjects.** Features of the constructive hierarchy of biomedical equipment, designs of the second level of complexity, block frames. Planar optical waveguides. Methods of matching optical integrated circuits with fiber optic cables and radiation sources. Active devices of integrated optics. Electro-optic modulators and deflectors. Semiconductor photodetectors. Optoelectronic integrated circuits. Integrated-optical devices for information transmission and processing systems. Integrated-optical generators, multipliers, switches, mixers, signal correlators. Influence of external destabilizing mechanical and climatic factors. Characteristics of vibration-shock resistance and temperature stabilization systems of biomedical equipment. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.** **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [4,P.23-34;6,P.33-49;8,P.87-101].**	**3**
8	**Absorption optoelectronic methods of studying bioobjects.** Fiber-optic indicatrix meters of scattered radiation during the interaction of a laser beam with biological objects. Basic optical schemes of fiber-optic meters using modern fiber-optic single-mode paths with preservation of polarization of laser radiation. **List of didactic aids:** Lecture notes; multimedia projection equipment; **Power Point presentation.**. **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [10,P.63-84;11,P.53-69;12,P.67-19.].**	**3**

9	**Schematics of strain-resistive and fiber-optic tip-transducers of blood pressure.** Transducers of biomechanical and bioacoustic quantities. Fiber-optic transducers for measuring Raman laser radiation. Main characteristics of fiber-optic modules and systems for modern meters in medical diagnostic systems. Features of designing structures of biomedical devices and preparation of the necessary technological documentation for implementation in production using the Solid Works Simulation design system. **List of didactic aids: Lecture notes; projection multimedia equipment; Power Point presentation.** **Tasks for the SRS:** **1. Repeat the lecture material, prepare for practical classes on these sections, study of literary sources [10,P.73-94;11,P.63-89;12,P.97-105.].**	**3**
Total hours		**26**

Practical classes

The main tasks of the cycle of practical classes: consolidation in practice of the main provisions of the academic discipline **"Biomedical Sensor Systems"** by performing specially formulated tasks and real circuit-technical options for designing printed modules and assemblies of biomedical equipment, which is actually designed in the master's theses of students. The practical class includes conducting a control of knowledge, skills and abilities, solving real problems of designing biomedical equipment with their discussion, solving control tasks, checking them and evaluating them.

The grades received by the student for individual practical classes are entered into the journal of the study group and are taken into account when determining the final grade (rating) for this academic discipline.

№ s/n	**Class Subject Name**	**Number of hours**
1	Interaction of optoelectronic radiation with medium and large particles.	**4**
2	Features of scattering of optoelectronic radiation from blood formed elements..	**4**
3	Computer modeling of processes of interaction of optoelectronic radiation with blood formed elements.	**4**
4	Computer methods of processing speckle structure of optoelectronic radiation scattered by microbioobjects.	**4**
5	Determination of parameters of liquid blood medium using indicatrix of scattering of optoelectronic radiation.	**4**
6	Energy and phase characteristics of optoelectronic radiation scattered by spherical microbioparticles.	**4**
7	Spatial and temporal coherence of optoelectronic radiation. Measurement schemes.	**2**
8	Features of interference and diffraction of optoelectronic radiation. Modern methods and devices for processing biomedical diagnostic information.	**2**
Total hours		**28**

Laboratory classes - none

Individual tasks

An individual assignment in the form of an ***ABSTRACT*** is planned for this credit module.

The main objectives of the individual task: An abstract is a task that involves solving a specific practical educational task based on the materials of the theoretical volume of the discipline **"Biomedical Sensor Systems"** using known, as well as independently studied theoretical material on the design and construction of modern laboratory analytical devices for a wide range of purposes. A significant part of such work consists of graphic material, which is performed in accordance with current regulatory requirements and with the mandatory use of computer graphics, if this is determined by the task, and using modern software systems for designing optoelectronic diagnostic devices for analytical purposes. Tests, as well as calculation works, may include certain illustrative material.

Approximate topic (name of individual task):

1. Classification of modern laser and optoelectronic devices.
2. Methods of pumping lasers, creating inversion, population of energy levels.
3. Features of quantum amplification and generation of laser radiation.
4. Interaction of laser radiation with biological objects.
5. Features of interaction of laser radiation with small particles.
6. Interaction of laser radiation with medium and large particles.
7. Features of scattering of laser radiation from blood elements.
8. Mathematical model of interaction of laser light with small particles.
9. Mathematical methods of analysis of optical characteristics of various objects.
10. Modeling of scattering indicatrix for biological objects.
11. Computer modeling of processes of interaction of laser radiation with blood elements.
12. Determination of microparticle parameters using computer processing of scattering indicatrix.
13. Computer methods for analyzing laser radiation scattering processes.
14. Influence of microparticle parameters on laser scattering indicatrix.
15. Features of laser radiation scattering from human blood.
16. Computer methods for modeling laser radiation scattering from biological objects.
17. Computer methods for processing the speckle structure of laser radiation.

Topics of individual tasks are added to the work program. (Appendix No. 2)

The abstract is a current control measure that involves solving a specific practical educational task based on the materials of the theoretical volume of the discipline **"Biomedical Sensor Systems"** using known, as well as independently studied theoretical material on the design and construction of modern laboratory optoelectronic analytical devices of wide application. A significant part of such work consists of graphic material, which is performed in accordance with current regulatory requirements and with the mandatory use of computer graphics, if this is determined by the task, and the use of modern software systems for designing biomedical equipment of laboratory analytical purpose. The RGR covers practical skills in applying modern tools and technologies for searching, processing and analyzing information, researching interdisciplinary areas related to biomedical engineering, critically analyzing the results of one's own research and the results of other researchers in the context of the entire complex of modern knowledge on the problem under study. **Modular control work (MCR)** is a current control measure that covers practical skills in the application of optoelectronic biomedical laboratory research tools for quantitative determination, analysis and evaluation of functional systems and processes of interacting natural and artificial systems, which will allow: to research, develop, apply, improve and implement solutions, tools and methods of modern laboratory optoelectronic research, as well as methods and technologies of medical and bioengineering to solve problems related to human health and quality of life; to solve tasks and problems of bioengineering for the artificial creation or replacement of cells, tissues and organs of the human body, for artificial improvement and correction of their functions, and the development of laboratory optoelectronic diagnostic technologies, tools and systems on this basis.

Control tasks for modular control work are attached to the working curriculum.

Extracurricular activities It is expected that within the framework of studying the academic discipline, at least two field trips will be held - based on modern laboratory diagnostic medical centers, as well as participation in Exhibitions of Modern Medical Instrumentation, in particular **"Healthcare 2024 and 2025"**, etc.

Distance learning platform: For more effective communication in order to understand the structure of the discipline **"Biomedical Sensor Systems"** and master the material e-mail, distance learning platform **"Sikorsky"** based on the **Moodle KPI-Telecom** system and service for online meetings **Zoom** are used, through which it is possible to : - simplify the placement and exchange of educational material; - provide students' feedback on learning objectives and content of the discipline; - evaluate students' learning tasks; - maintain the account of performance by students of the plan of academic discipline, the schedule of performance of educational tasks and their estimation.

5. Independent student work (ISW)

Types of independent work *(preparation for classroom classes, calculations based on primary data obtained in laboratory classes, problem solving, essay writing, calculation work, homework, etc.):* ***Independent work***

№ s/n	Names of topics and questions submitted for self-study and references to educational literature	Hours ISW
1	**Topic 1.1 Features of optoelectronic methods of biomedical research.** List of questions submitted for independent study: Features of the system of automatic design of biomedical equipment. Complex of design tools. Necessary divisions of design organizations. [3,P.34-78;5,P.26-52;7,P.47-59].	**12**
2	**Topic 2.1 Photodynamic effect of endogenous sensitizer. Interaction of optical radiation with bioobjects.** List of questions submitted for independent study: Principles of completeness, development, compatibility, standardization and inventory, inclusion and accumulation of experience. Mathematical formulation of the problem of designing biomedical equipment, selection of numerical methods of analysis, development of a design algorithm, mathematical models and methods. [2, P.19-25; 3, P. 41-53; 4, P. 10-17.].	**9**
3	**Topic 2.2. Optical methods in laboratory diagnostics.** List of questions submitted for independent study: Features of using software in the design of printed assemblies and components of biomedical equipment. Application of modern software products for automated design, production of technical and technological documentation when implementing the proposed design solutions in production. [4, P.34-58;7, P.26-47;9, P.38-51.].	**10**
4	**Topic 2.3 Basic concepts of measuring transducers .**	**10**

№ s/n	Names of topics and questions submitted for self-study and references to educational literature	Hours ISW
	List of questions submitted for independent study: Features of the generalized algorithm for automated design of biomedical equipment, interaction of software and methodological complexes and software and technical complexes. The set of interactions of all structural elements of CAD of biomedical equipment. [4, P. 28-43; 6, P. 37-51; 9, P. 48-62.].	
5	**Topic 2.4 Metrological characteristics of measuring biomedical transducers.** List of questions submitted for independent study: The spectrum of properties, parameters and characteristics of information support of CAD as a technical system. Features of problem-oriented complexes of technical means of automated design of biomedical devices and complexes. Functional groups of general-purpose technical means for the design of biomedical equipment. [2, P.25-38; 7, P.46-53; 9, P.67-81.].	**10**
6	Topic 2.5 Schemes of strain-resistive and fiber-optic tip-transducers of blood pressure. List of questions submitted for independent study: Mathematical models of processes that are carried out in biomedical equipment. Probable characteristics of a set of random variables in the process of designing biomedical equipment. Basic structural and design modules of the first level **(SCM1).** [2, P.15-28;8, P.25-47;10, P.44-57.].	**7**
7	**Topic 3.1 Biomechanical and bioacoustic transducers.** List of questions submitted for independent study: . Features of automatic tracing of printed conductors of electronic modules of biomedical equipment in the Dip Trace system. Production of technological documents for the design of biomedical equipment in the Solid Works Simulation system. Features of the design of structures of biomedical devices and the preparation of the necessary technological documentation for implementation in production using the Solid Works Simulation design system. [10,P.73-94;11,P.63-89;12,P.97-105.].	**8**
Total hours		66

Policy and control

6. Policy of academic discipline (educational component)

Rules for Attending Classes

Attendance at lectures and practical classes, as well as absence from them, is not assessed. However, students are recommended to attend classes, as they teach theoretical material and develop the skills necessary for completing the semester individual assignment. The assessment system is focused on obtaining points for student activity, as well as completing assignments that are able to develop practical skills and abilities.

Incentive points

Incentive points	
Criterion	Weighted score
Performing practical work	5 points
Writing theses, articles, and designing a thesis as a scientific paper for participation in a student scientific paper competition	5 points for each type of activity (2 theses or one article, or design of creative work as a scientific paper for participation in the student scientific paper competition)
Timely writing of MCR	4 points
Timely submission of the test	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 " ***Therapeutic medical equipment*** *" can be taught to most students with special educational needs, except for students with severe visual impairments that do not allow to perform tasks using personal computers, laptops and / or other technical means.*

Distance education

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

Distance education 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.

On 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.

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

Types of control and points for each control element:

№ s/n	Control measure	%	Weight points	Number	Total
1.	*Express control work / test tasks*	18	1	18	18
2.	*Completion and defense of practical work*	18	2	9	18
3.	*Modular test work*	44	1	1	44
4.	*Abstract*	20	20	1	20
5.	*Test work*	40	40	1	80
	Total				100

It is taken into account in the total rating together with the grade for the essay if the student did not score 60 points for the semester or he wants to improve his grade.

Current control: *modular test, distance learning assessment*

MCR evaluation system

№ s/n	Control measure	%	Weight points	Number	Total
1.	Timely registration	10	10	1	10
2.	The correct answer to each question (solution)	10	10	9	90
	Total				≤100

Abstract evaluation system

№ s/n	Control measure	%	Weight points	Number	Total
1.	Timely registration	10	10	1	10
2.	The correct answer to each question (solution)	10	10	9	90
	Total				≤100

Grading for distance learning by transferring the results of online courses in the **Moodle** system is provided only for control questions and test results for completing an individual task.
Grading for control measures (practical work, modular test work) by transferring the results of online courses is not provided.

№ s/n	***Distance learning***	*%*	***Weight points***	***Number***	***Total***
1.	Answering test questions in the online system **Webex** or **Zoom**	40	10	4	40
2.	Answering tests in the system **Moodle**	50	10	5	50
3.	Timeliness of distance learning	10	10	1	10
	Total				100

If academic misconduct is detected during distance learning, the control measure is not taken into account, and the student is not allowed to defend his/her thesis.

Calendar border control

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.

<table>
<tr><th colspan="3">Criterion</th><th>The first CC</th><th>The second CC</th></tr>
<tr><td colspan="3">Deadline of calendar controls</td><td>8th week</td><td>14th week</td></tr>
<tr><td rowspan="7">Conditions for obtaining a positive result from the calendar control</td><td colspan="2">Current rating</td><td>≥ 24 points</td><td>≥ 40 points</td></tr>
<tr><td rowspan="2">Execution of practical work</td><td>PW № 1- 6</td><td>+</td><td>+</td></tr>
<tr><td>PW № 7-12</td><td>-</td><td>+</td></tr>
<tr><td rowspan="2">Express control works / test tasks</td><td>At least 4 of any lectures</td><td>+</td><td>-</td></tr>
<tr><td>At least 8 of any lectures</td><td>-</td><td>+</td></tr>
<tr><td>Modular control work</td><td>Estimated MCW</td><td>-</td><td>+</td></tr>
<tr><td>Abstract work</td><td>Estimated AW</td><td>-</td><td>-</td></tr>
</table>

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

Semester certification of students

Mandatory condition for admission to the test		*Criterion*
1	*Current rating*	*RD ≥ 42*
2	*Obtaining a positive assessment for the performed Abstract work*	*More than 8 points*
3	*All practical works are tested*	*More than 14 points*
4	*Writing at least 6 express tests / tests*	*More than 6 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 of 50% of lectures.*

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

Number points	*Assessment on the university scale*
100-95	*Perfect / Відмінно*
94-85	*Very good / Дуже добре*
84-75	*Good / Добре*
74-65	*Satisfactorily / Задовільно*
64-60	*Enough / Достатньо*
Less 60	*Unsatisfactorily / Незадовільно*
Admission conditions are not met	*Not allowed / Не допущено*

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. Students have the right to challenge the results of the control measures, but it is obligatory to explain, with which criterion they do not agree according to the assessment letter and / or comments.

Additional information about the exam / test / interview:

The student has the right to improve their scores on the module test in the case of its timely writing in the scheduled class. Students are not allowed to use lecture notes or mobile devices during the test. It is allowed to use computer technology and educational and methodical support for practical classes.

8. Additional information on the discipline (educational component)

List of questions submitted for semester control for modular control work:

1. Laser analyzers of human blood parameters. Schemes, characteristics.
2. Laser flow cytometry devices. Schemes, characteristics.
3. Application of lasers for the diagnosis of human blood diseases.
4. Laser therapeutic devices. Schemes, characteristics.
5. Application of UV lasers in medicine. Schemes, characteristics.
6. Application of IR lasers in medicine. Schemes, characteristics.
7. Effect of UV and IR radiation on biological objects.
8. Laser nephelometers. Principle of operation, optical schemes, designs.
9. Application of lasers for irradiation of human blood. Schemes, characteristics.
10. Modern laser devices for measuring sugar content in human blood. Schemes, characteristics.
11. Modern laser scalpels on CO2 and solid-state lasers.
12. Fiber-optic medical endoscopes. Designs, characteristics.
13. Application of lasers in ophthalmology. Schemes, designs.
14. Application of lasers in oncology. Schemes, designs.
15. Application of lasers for therapy. Schemes, designs.
16. Application of lasers for the diagnosis of diseases. Schemes, designs.
17. Application of lasers in surgery. Schemes, designs.
18. Application of lasers for the treatment of human skin diseases, cosmetology.
19. Application of He-Ne lasers for the treatment of cardiovascular diseases. Schemes, characteristics.
20. Application of laser spectrophotometers for the diagnosis of human blood diseases. Schemes, characteristics.Можливість зарахування сертифікатів проходження дистанційних курсів

Distance learning through online courses in the Moodle system on a specific topic 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 using such courses is allowed, but students must complete all tasks provided for in the academic discipline (practical work, modular test work, calculation and graphic work).
The list of distance courses is provided on the website of the **Department of Biomedical Engineering** of **Igor Sikorsky Kyiv Polytechnic Institute**: **http://bmi.fbmi.kpi.ua/non-formal-education**

9. Applications

Appendix 1. Program learning outcomes (extended form)

As a result of studying the academic discipline "Biomedical Sensory Systems", students will be able to:

Learning outcomes		Correspondence of learning outcomes to the competencies of the SVO [6]	
		General Competence (soft skills)	Special competence (professional)
PRN 3	Manage complex activities or projects, be responsible for making engineering decisions in unpredictable conditions, conduct feasibility and safety assessments of projects (Reinforcement).	ZK 1 Ability to apply knowledge in practical situations. (Reinforcement).	FK 2 Ability to provide engineering and technical expertise in the planning, development, evaluation, and specification of medical equipment (Reinforcement).
PRN 7	Manage complex activities or projects, be responsible for making engineering decisions in unpredictable conditions, conduct feasibility and safety assessments of projects (Reinforcement).	ZK 2 Knowledge and understanding of the subject area and understanding of professional activity (Reinforcement).	FK 7 Ability to plan, design, develop, install, operate, maintain, service, control and coordinate the repair of devices, equipment and systems for prevention, diagnosis, treatment and rehabilitation used in hospitals and research institutes (Reinforcement).
PRN 10	Be able to plan, organize, direct and control medical and bioengineering systems and processes (Reinforcement).	ZK 4 Skills in using information and communication technologies (Reinforcement).	FK 2 Ability to provide engineering and technical expertise in the planning, development, evaluation, and specification of medical equipment (Reinforcement).
PRN 13	Be able to analyze signals transmitted from organs to devices and process diagnostic information (signals and images) (Reinforcement).	ZK 4 Skills in using information and communication technologies (Reinforcement).	Knowledge of the principles of development and modern problems of creating biosensor nanoelectronic diagnostic systems and implementing research results into medical practice.

PRN 22	Knowledge of general principles and structure of complex biological systems, including the human body and its functions from the perspective of a systemic approach and their utilization in biomedical engineering, as well as basic methods and tools used for quantitative assessment of physiological system functioning (Reinforcement).	ZK 1 Ability to apply knowledge in practical situations. (Reinforcement).	FK 7 Ability to plan, design, develop, install, operate, maintain, service, control and coordinate the repair of devices, equipment and systems for prevention, diagnosis, treatment and rehabilitation used in hospitals and research institutes (Reinforcement).
PRN 23	Development and implementation of modern diagnostic and therapeutic methods associated with the use of biotechnology, computer, and nanotechnology through the improvement of technical elements of medical devices and systems, as well as medical products, in the process of professional activity (Reinforcement).	ZK 2 Knowledge and understanding of the subject area and understanding of professional activity (Reinforcement).	FK 2 Ability to provide engineering and technical expertise in the planning, development, evaluation, and specification of medical equipment (Reinforcement).
PRN 24	Being able to consider historical, social, environmental, ethical, legal, economic aspects, requirements of labor protection, industrial hygiene, and fire safety when forming technical solutions, taking into account the strengthening and preservation of personal and public health (Reinforcement).	ZK 13 The ability to preserve and multiply the moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and engineering, to use various types of physical activity for active recreation and leading a healthy lifestyle (Reinforcement).	FK 12 Ability to ensure and monitor compliance with safety and biomedical ethics when working with medical equipment (Reinforcement).

Appendix 2. Methodological recommendations for writing and formatting an Abstract

One of the main types of semester control during the mastering of the academic discipline **"Biomedical Sensor Systems"** is the execution of an essay. The essay is performed in accordance with the requirements, within the period specified by the teacher.

The main objectives of the individual essay assignment are a task that involves solving a specific practical educational task based on the materials of the theoretical volume of the discipline **"Biomedical Sensor Systems"** using known, as well as independently studied theoretical material on the design and construction of modern optoelectronic diagnostic analytical devices for a wide range of medical purposes. A significant part of such work consists of graphic material, which is performed in accordance with current regulatory requirements and with the mandatory use of computer graphics, if this is determined by the assignment, and using modern software systems for the design of optoelectronic diagnostic analytical devices for laboratory purposes. Control work, as well as calculation work, may include certain illustrative material.

The abstract addresses the following main issues:

1. Optoelectronic diagnostic complex for cardiological research. Schemes, features of operation.
2. The use of computers for the diagnosis of heart diseases. Modeling the work of the human heart.
3. Methods of active thermography using hyperbaric oxygenation.
4. Modern electrocardiography devices. Schemes, characteristics.
5. Acoustic and holographic thermography. Schemes, characteristics.
6. Modern methods of thermographic diagnostics. Schemes, characteristics.
7. Modern diagnostic complexes for optoelectronic laboratory and clinical research. Principle of operation. Schemes, characteristics.
8. Modern autoanalyzers. Features of operation, schemes, characteristics.
9. Modern UV spectroscopy devices. Features of operation, schemes, characteristics.
10. Modern fluorometers. Features of operation, schemes, characteristics.
11. Modern optical laser cytometers. Features of operation, schemes, characteristics.
12. Optoelectronic systems for the study of human blood parameters. Features of operation, schemes, characteristics.
13. Optoelectronic complexes for studying optical characteristics of biological objects. Features of operation, schemes, characteristics.
14. Diagnostic optoelectronic equipment for recording human biopotentials. Features of operation, schemes, characteristics.
15. Features of operation of devices for electromyography and electrogastrography. Basic schemes, characteristics.

The title page of the **abstract** should have the following content: name of the university; name of the faculty; name of the department; name of the specialty, name of the educational and professional program, registration number, name of the academic discipline; topic of the abstract; surname and first name of the student, course, academic group number, year.

The title page is followed by a detailed plan (content of the abstract, which should include an introduction, 3 sections of the main content (analysis of literary sources, description of the functional scheme, calculation of the functional block or software development), their subdivisions (if necessary), conclusion, list of sources used. The page numbers of the beginning of each question are indicated on the right in the table of contents. Each section begins with a new page.

The total volume of the **abstract**, depending on the chosen topic, can vary from 30 to 40 pages of the main text (upon agreement with the teacher). The volume of the abstract is determined by the student's ability to briefly and at the same time comprehensively reveal the topic: the relevance of the topic under consideration, modern trends and problems, analyze the best foreign and Ukrainian technologies, draw conclusions and justify their own proposals and recommendations.

An abstract is provided in two languages - Ukrainian and English, indicating keywords.

Mandatory requirement: clear reference to sources of information. All figures, facts, opinions scientists, quotes, formulas must have references in the form of [2, p.54] (the first digit means the number of the source in the list of literature given at the end of the creative work, and the second digit is the page number in this source). It is advisable to use tables, diagrams, graphs, charts, etc. The list of sources used (at least 10 sources) is drawn up in accordance with the current rules. If the information is taken from the Internet, it is necessary, as for ordinary literature, to indicate the author, the title of the article, and then give the address of the site on the Internet.

The abstract is evaluated according to the criteria: logicality of the plan; completeness and depth of disclosure of the topic; availability of illustrations (tables, figures, diagrams, screenshots of web pages, etc.); number of sources used and clarity of references to them; reflection of practical materials and calculation results; design; substantiation of the student's own opinion on this issue in the form of a conclusion.

Deadline for submitting an abstract for verification: 10 days before the start of the credit session.

The abstract is not checked for plagiarism, but must meet the requirements of academic dishonesty. If academic dishonesty is detected, the work is canceled and not checked.

Work program of the discipline "Biomedical Sensor Systems" (syllabus):

Compiled *by Associate Professor of Biomedical Engineering,* ***Mykola Bogomolov****.*

Approved by the Department of Biomedical Engineering (protocol № 16___ to 21.08.2024).

Approved by the Methodical Commission of the Faculty of Biomedical Engineering (protocol № 9 to 26.09.2024).[1]

The syllabus template has been approved by the university's methodological council.